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REGULAR SKEWNESS OF BIRTH ORDER DISTRIBUTION

By Carl-Gustaf Berglin

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By Carl-Gustaf Berglin

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Department of Social Medicine, Uppsala University

ABSTRACT

Berglin, C.-G.: Regular skewness of birth order distribution.

Studies published since a century indicate that statements concerning connections between birth order and sociomedical problems have been numerous but very often conflicting. In the 1950's the author found that older alcoholics were more often elder siblings, young alcoholics more often younger siblings, as if some regular mechanism made families bring forth specific ranks of children, sometimes more earlyborn, sometimes more lateborn. A logical analysis showed that this was a plausible idea. In numerical form it entailed the construction in 1959 of a population model built on census information regarding fertility and average sibship size in cohorts of the general population. Though the position of a certain individual in his sibship may vary between 0 and 1 around a mean position of .5, the mean position of a birth cohort is always skewed, in some cases deviating from .5 by .1 or more. Three samples of sociomedical patients, 2,000 persons in all, showed a characteristic skewness of mean position, varying from birth cohort to birth cohort and forming a marked pattern which repeated itself when subgroups were formed. This empirical pattern coincided closely with the pattern predicted by the population model. A sample of 302 university students, on the other hand, deviated significantly from the population model, suggesting an overrepresentation of earlyborn.

The study demonstrates the existence of a regular pattern of skewed birth order distribution in sociomedical cases and points to definite population mechanisms causing skewness. Crossvalidation confirmed these statements. The idea of a balanced birth order distribution within a birth cohort is therefore severely misleading. Balanced distribution in a sample may in reality point to a significant deviation, whereas skewed distribution may be a result of random selection from the general population. The cohort model mentioned above is suggested by the author as a rapid means of estimating the degree of skewness always present in the birth order distribution of the general population.

Key words: birth order, birth intervals, parent-child relations, sibling relations, family size, population distribution, university students, neurosis, schizophrenia, alcoholism.

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SOME TERMS

Sibship terms

Sibship (family): The propositus and all his siblings, from firstborn to lastborn, including dead siblings.

Family: Sibship.

Incomplete sibship: Sibship to which a new member could be added by a mother below the age of 45.

Sibship size: Sum of sibship members. Symbol: s. Unit: Arabic numeral (1, 2, 3 . .).

Sibling (sib): Brother, sister, sometimes half-sibling and step-sibling, according to definition in the text (section 3: 11).

Interval: Age difference between siblings of adjacent rank.

Birth order terms

Rank (birth order): Ordinal number of sibling, from oldest (firstborn) to youngest (lastborn) sibling. General symbol: r. Unit: Roman numeral (I, II . .).

Place: Midpoint of ordinal space, expressed as ordinal number value minus one half, $(r - 1/2)$. See fig 5: 2.

Position (relative position): Midpoint of ordinal space related to sibship, place value divided by sibship size, $(r - 1/2)/s$. Symbol: p.

Median (middle child): The median person of an uneven number of sibship members, for example IV of 7. Symbol: M. Rank: $(s + 1)/2$.

Senior (earlyborn child): Sibling belonging to the older half of a family (not a Median), for example I and II of 5. Symbol: S. See fig 5: 2.

ıg belonging to the younger half of a family (not a Median), for example III and IV of 4. Symbol: J. See fig 5:2.

Intermediate: Sibling belonging to the members between firstborn and lastborn, for example II and III of 4.

Laterborn: Not firstborn, for example II, III, and IV of 4.

Absolute excess: More J than S (symbol $J_X = J–S$) or more S than J (symbol $S_X = S–J$).

Net excess: J excess in one part of the population, minus S excess in another part, $(J_X - S_X)$. Symbol: N_X.

Relative excess: Net excess individuals in relation to all individuals in the population. Symbol: N_X/N.

Skewness: A significant deviation from .5 of the mean position of an age group.

Sampling terms

Propositus: Person sampled according to some quality, for example being a student or a patient.

Q-sample: Sample of propositi, all of whom are carriers of the quality investigated, for example being a delinquent.

R-sample: Sample of propositi, a ratio of whom are carriers of the quality investigated, for example the ratio of anxious persons among firstborn and laterborn.

Control sample: Persons sampled for comparison, belonging to a general population, usually matched in one or more respects.

Contrast sample: Persons sampled for comparison, belonging to a non-general population, usually matched (for example persons registered in some association or in a directory).

Population terms

General population: The totality of persons defined by some place of residence.

Basic population: Hypothetic population stratum containing all persons living in the background situation that is supposed to be able to produce the trait-carriers of the sample. The background may be genetically, physically, culturally, or otherwise determined (6:4).

Birth cohort: All persons born alive during a defined period of time (a day, a year, a decade).

Birth cohort of a birth place: All persons born alive in a defined area during a defined period of time; for example born in certain parishes in 1915–19, including those who later died or emigrated.

Birth cohort of an abode: All persons born during a defined period of time and resident in a defined area at a defined period of time; for example born in 1915–19 and living in certain parishes in 1980, including immigrants.

Dissemination period: Any period of time that is as long as the averaged sibling interval pertaining to the period. Symbol: w.

Disseminate: Birth cohort of a dissemination period (7:2).

Dissemination column: Persons randomly sampled from a disseminate within some general population. Symbol: D. (Persons sampled by some specific quality Q_a do not form a disseminate, though they may happen to have another quality Q_b in common with a disseminate.)

Notation of sections, tables, figures, and formulas

Section	5:3	denotes	the	third	section	of	chapter	five. Symbol: 5:3.
Table	5:3	"	"	"	table	"	"	". Symbol: tab. 5:3.
Figure	5:3	"	"	"	figure	"	"	". Symbol: fig. 5:3.
Formula	5:3	"	"	"	formula	"	"	". Symbol: form. 5:3.

SYMBOLS

d : difference between means (5:6)
D : dissemination (5:7; 7:2)
i : index of more recent point in time (lower age)
j : " " an earlier " " " (higher age)
J : Junior sibling (lateborn)
L : laterborn (not firstborn)
M : Median sibling
n_s : number of propositi from family size s
n : number of propositi in a total sample
n_s/s : number of families corresponding to n_s
n/s : " " " " " a total sample
N : total population between two age limits
N_x : net excess of J or S members within N
N_0 : non-excessive members of N; $N_0 = N - N_x$
P : probability ot random deviation
p_s : position of a sibling of rank r in his sibship; $p_s = (r - 1/2)/s$
$\bar{p}_s$: mean position of n_s propositi
p_{tot} : mean position of n propositi
p, q (in 3:8): proportions of trait-carriers and non-trait-carriers; $p + q = 1$
r : birth rank
s : family size (sibship size)
S : Senior sibling (earlyborn)
t : period of time
w_s : mean sibling interval in size s
w : " " " " a total sample
I, II, III, etc.: firstborn, secondborn, thirdborn, etc.

INTRODUCTION

The analysis presented here deals with problems concerning birth position. It is a work of slow maturation. More than forty years ago, my teacher in forensic psychiatry, Professor Olof Kinberg, called my attention to Cyril Burt's "The Young Delinquent" and to his misgivings about the fate of only children like myself. Twenty years later I had an agreeable correspondence with Sir Cyril on the analysis of variance but I avoided mentioning my birth order problem. At that time I had been working as a social medical officer in Gothenburg since 1946 and had carried out several hundred disulfiram treatments. My experience of these cases was published in 1960 (and commented upon in The Lancet), but I explicitly excluded the birth order correlations since they appeared to be "an illusion caused by demographic mechanisms". Older alcoholics were mainly older siblings, young alcoholics mainly younger siblings.

The challenge of the riddle resulted in a manuscript of 15 pages, written in 1959 and covering the main part of chapter 7 in this book. The late Professor Hannes Hyrenius advised me to enlarge the material and to crossvalidate my methods which he found rather unconventional. They were entirely the issue of autodidactic trials. Mrs Margareta Garai and Miss Ingalill Andersson collected further birth order data. The first crossvalidation was performed by Lennart Holmgren in his presentation of 722 cases in 1960. Shortly afterwards Professor Ragnar Berfenstam acquainted himself with my results and discussed them for the first time.

It had become apparent that questions of sibling interval must be kept under detailed control in the numerical analysis of sibling position. Therefore new material that also contained information concerning sibling interval was sampled in the years that followed up until 1973. At that juncture I was working at the University of Gothenburg. The Chairman of the Department of Social Medicine, Professor Bengt Lindegård, exhorted me to end the sampling and to give the material a definite form. He also advised me in the description of the background and sampling of my cases and in the disposition of references.

From the autumn of 1974 onwards I rearranged the material, building and rebuilding models, readjusting ideas and correcting numerous mistakes. At the same time I began to make myself acquainted with previous work in the field and found that some of my ideas had been elaborated around 1910 by Weinberg and by Greenwood and Yule. My main finding in 1959 had been that the mean sibling position in any population must necessarily deviate from .5. This mechanism, predicted by J A Cobb in 1914, was later discussed in general terms by Hare and Price in 1969 and by Birtchnell in 1971. Literature certainly helped me to survey the many varieties of method that had hitherto been used, but apart from the authors mentioned above nobody seemed to have been aware of the problem of skewed distribution of birth orders. My rearrangement of formulae and models was a result of continued practical work and unceasing reconsideration of my original ideas. Numerous corrections proved necessary but they involved no radical alterations.

Continual discussions with the experienced statistician Bo Eriksson meant a great support in this work over several years. Associate Professor Calle Bengtsson procured information regarding family size. Dr. John Birtchnell, Chichester, England, and Dr. R.B. Zajonc, Ann Arbor, USA, sent me new material together with their personal comments. The Chairman of the Department of Mathematical Statistics, Professor Peter Jagers, Gothenburg, read the first version of the new manuscript in July 1979. His comments and encouragement, as well as his generosity in having the manuscript technically checked by Claes Löfgren, assistant at his department, have been of decisive practical and moral importance to me. Associate Professor Adam Taube and Associate Professor Leif Lindblad have advised me in several respects. Professor Ragnar Romanus has devoted much time to questions of publication. Professor Per M. Lundin and Professor Sven Lindstedt have given me practical advice and aid. To all the persons mentioned above I am greatly indebted for their interest and support.

My particular gratitude is due to Professor Ragnar Berfenstam, Chairman of the Department of Social Medicine at the University of Uppsala, for his deep-going scrutiny of the manuscript and for his constructive criticism. Although I am entirely responsible for the final formulations and statements of the work, it could not have reached publication at this point without his advice and help.

Ultimately, I have a deeply personal gratitude I wish to express at this phase of my life: to Anna M. Skotte (1880–1942) and to Carl D. Berglin (1873–1934). I need not go into reasons why this book is dedicated to their memory.

Chapter 1

THE PROBLEM: SKEWNESS OF SIBLING POSITIONS AS A SOCIOMEDICAL DETERMINANT

1:1. THE NATURE OF THE PROBLEM

This investigation started from the hypothesis that sociomedically important diagnoses, for example schizophrenia, may be more common in certain sibling positions, either among earlyborn or lateborn. Therefore birth rank and sibship size were registered in hundreds of sociomedical cases. A survey of a group of alcoholics and a survey of groups with other symptoms led to ambiguous results. Birth order distributions differed much more between birth cohorts than between symptom groups. It was therefore necessary to eliminate the source of error represented by birth cohorts.

This can be done by comparing the propositus group to a control group with the same age distribution. In this case, a large material must be sampled from the corresponding general population in order to create age groups which can be combined into an age-specified control group. If the propositus group represents a mixture of natives from rural, market-town and city areas, the sampling may necessitate extensive arrangements.

If it were possible to ascertain, not only the fact *that* age groups or geographical groups in the general population differ as to birth order distribution, but also reasons *why* they differ and methods estimating *how much* they differ and *in what direction*, such knowledge would lead to a deeper insight into problems of birth order distribution. Skewed distributions are not due to random influences but to rational principles which allow the construction of cohort models built on comprehensive population statistics.

The problem had started as a narrow question dealing with connections between sociomedical symptoms and sibling position as a social agent. It rapidly widened into a methodological problem. The empirical surveys indicated that earlyborn prevail in some birth cohorts, lateborn in other birth cohorts. If that is so, all samples of trait-carriers are influenced by a skewness of mean sibling position; sometimes in one direction, sometimes in another.

What laws govern these deviations? How can we predict the direction and the size of a deviation without resorting to actual control samples? How can such a method help us to estimate the regular skewness of birth order distribution in a general population and to prevent misleading conclusions from a skewed distribution found in a propositus sample?

These are the problems which the subsequent chapters will analyse and suggest solutions to.

1:2. AN ORIENTATION

According to most people, common sense ought to tell us that there should be as many lastborn as firstborn in the general population, as many persons representing earlier as later parts of their sibships. There should be as many second as fourth or fifth children coming from sibships of seven (fig 1:1).

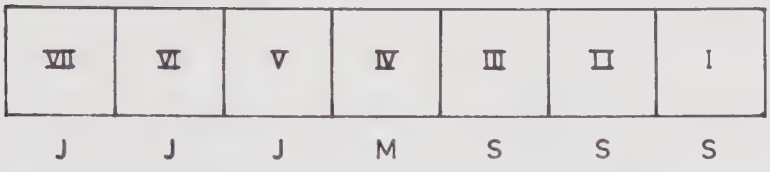


Fig 1: 1. Model of a sibship. I: firstborn. VII: lastborn. II, III, IV, V, VI, VII: laterborn. S: Seniors (earlyborn). M: Median child. J: Juniors (lateborn). Intervals disregarded.

In a sample of total sibships, we may safely state that members of all family sizes occupy positions which are perfectly balanced around a position in the exact middle. The mean position of .5 is thus true for each total family unit, as well as for a sample of total units of all kinds.

Now, if somebody samples propositi according to a certain characteristic or trait, for instance that of being a college student, or a delinquent, or a depressive patient, and he finds more firstborn than lastborn in the sample, it may seem natural to talk about an "overrepresentation" of firstborn, and to suppose a connection between birth order and trait. In social medicine and social psychology it has been customary for more than a century to register such "overrepresentation" for use in the analysis of mechanisms behind a group characteristic.

A true overrepresentation, however, implies that a certain sibling position is significantly more common among propositi than in a matched sample of the general population. A significant difference between two subgroups of propositi (for example college students) is of limited interest as long as we do not know whether one of the subgroups, and which one (or both), deviate(s) from the general population.

The normal skewness of sibling positions in a population may be illustrated by means of some practical examples.

The case load of midwives contains a population of newborn. Those without siblings are single, those with siblings are all lastborn. This excess of lateborn will never automatically become balanced by earlyborn in other age strata. A population including the first years of life will have its skewness permanently influenced by an excess of lateborn.

Further, when a number of young couples move into an area that has hitherto been sparsely inhabited, they will raise children of about the same age. The kindergarten population of the area will in the beginning, contain mainly firstborn, after some years mainly secondborn and after many years perhaps chiefly lateborn. One has to expect the same

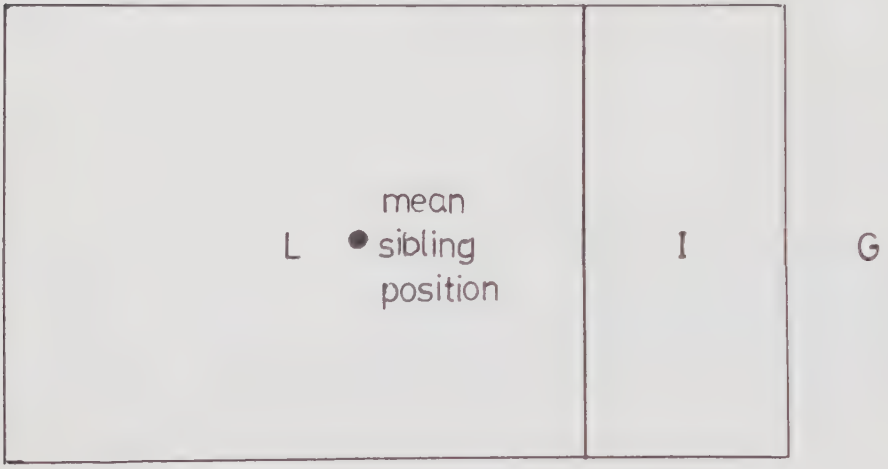


Fig 1: 2. General population (G) containing few firstborn (I) and many laterborn (L). Mean sibling position skewed in late direction.

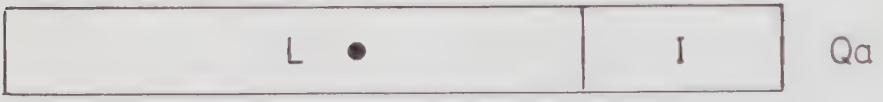


Fig 1: 3. Q-sample. 100% carriers of quality Qa. Mean position uninfluenced.

phenomenon in elementary school classes and among those liable for military service. An excess of earlyborn is always generated in samples from increasing birth cohorts, an excess of lateborn in age groups from decreasing birth cohorts.

Other conditions, such as family size or migration or mortality may exert influence in specific directions on average sibling position. It is perfectly feasible to produce, by random selection or by intentional choice of certain age groups, a combination of cohorts that can move the mean sibling position of a sample in any direction, or even, by sheer coincidence, place it in the middle.

Hence, before drawing conclusions from the birth order distribution of a sample in social medicine or social psychology, we have to ascertain whether that distribution deviates from the skewed distribution always present in the general population.

Fig 1: 4. Q-sample. 100% carriers of quality Qb. Firstborn overrepresented. Mean position at .50.

Fig 1: 5. Q-sample. 100% carriers of quality Qc. Firstborn heavily overrepresented.

We may illustrate the situation by means of figures that imitate real samples. Fig 1: 2 depicts a birth cohort of the general population (G) where 25 % are firstborn (I) and 75 % laterborn (L). Suppose a separate analysis has shown that there are more lateborn than earlyborn in the cohort. Therefore the high birth order numbers preponderate, so that the mean sibling position (marked by a dot) is pulled more than halfway from zero (to the right) towards unity (to the left), namely, to .55.

Many persons in G are carriers of a certain *quality* Qa, for example anaemia. A random sample of anaemic persons (fig 1: 3) will perhaps show the same proportion of firstborn, as well as the same mean position as the general population. Therefore no connection between Qa and birth order is indicated.

There are also many persons in G who carry a quality Qb, say a neurotic reaction pattern (neuroticism). A random sample of such persons (fig 1: 4) shows perhaps that the pattern is more common among firstborn. The mean position has moved nearer to the lower ranks. It stops in the middle, at .50 as it happens.

In our analysis of the anaemia example Qa we ought to choose our controls randomly from G, if possible. If we restrict ourselves to a comparison of sample Qa with a contrast sample Qb (neuroticism), we may perhaps find a significant difference of mean position between them but we do not know which of the two samples that deviates from G.

A third sample (fig 1: 5) has been selected by means of a quality Qc that constitutes no relative contrast to Qa but may be regarded as independent, for example the quality of being a college student.

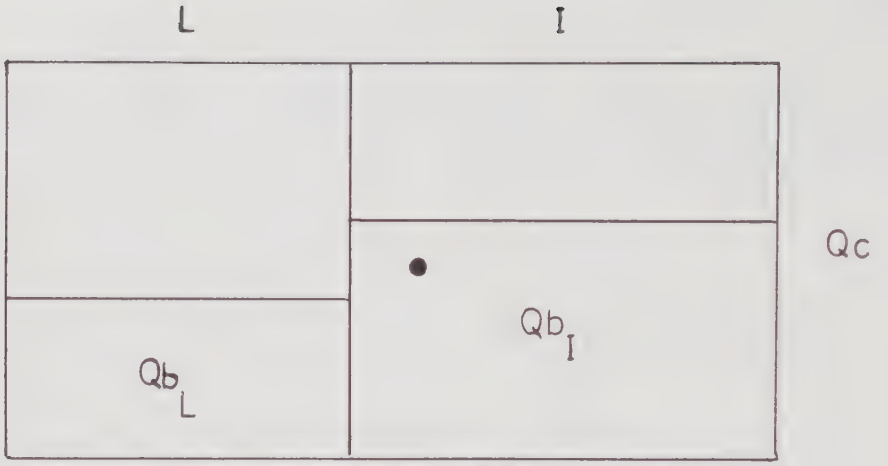


Fig 1: 6. R-sample. Ratio of Qb-carriers among firstborn and laterborn members of the Qc-sample.

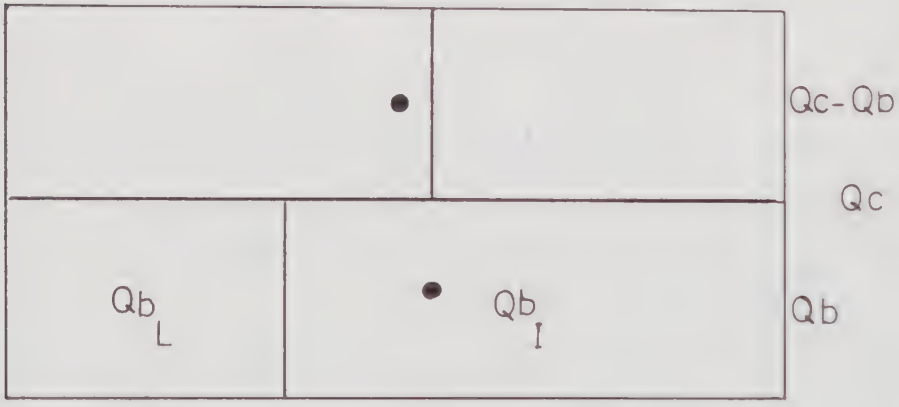


Fig 1: 7. R-sample. Ratio of firstborn and laterborn among Qb-carrying members of the Qc-sample.

In fig 1: 6 the student sample (Qc) is magnified and divided into subsamples of those who react neurotically (Qb) and those who do not. Among firstborn the number of Qb-members is Qb_I. Among laterborn students we find Qb_L members who react neurotically. (For convenience, Qb and Qc are also used here to indicate the quantity of persons who are carriers of the quality). Fig 1: 6 demonstrates a Q-sample (100 % students) arranged so as to show the *ratios* of carriers of another quality (neuroticism): an R-sample.

Fig 1 : 7 rearranges the same quantities in order to show the ratio of firstborn and later-born among trait-carriers (Qb) and among non-trait-carriers (Qc – Qb), thus another form of R-sample.

Obviously, a sample where all members are trait-carriers (a Q-sample) yields no useful information regarding the relationship between trait and birth order as long as we have not compared it with corresponding cohorts of the general population. Contrast samples are of dubious value: sample Qb in fig 1 : 4 even presents a mean position of .50 that does not deviate from an expected theoretical mean of .5, though it points, in reality, to a marked overrepresentation of firstborn.

On the other hand, a sample that presents a ratio of trait-carriers (an R-sample) certainly contrasts members with and without the quality to be analysed (Qb). It yields some information on birth order correlations of the quality Qb, but in a complicated pattern that still requires samples from G before we can interpret it. The number of firstborn among those showing Qb is determined by Qc and Qb in combination. An R-sample built on a broad principle of selection may resemble the general population rather closely, a sample numbering 100,000 tends to function like a G-sample containing a Q-sample.

Thus, a comparison of Q with controls from G is better than R, and R is superior to a comparison of Qa with Qb contrasts. An isolated Q is practically worthless but has been quite popular on the assumption that one can use a theoretical model for comparison, which is not the case.

Later chapters will consider these problems in greater detail and propose a solution that may simplify computations.

Chapter 2

HUMAN FATE AND BIRTH ORDER IN LITERATURE

2: 1. WHY ARE SIBLINGS DIFFERENT? A KNOTTY QUESTION.

Parents have no doubt always felt intrigued by the fact that their children are far from alike. Has this particular child taken after this or that ancestor or been educated in a special manner, perhaps due to its position in its sibship? Mythical siblings, such as Cain and Abel, Esau and Jacob, seem to illustrate relationships between firstborn and laterborn.

Rules of primogeniture have allotted special social roles to firstborns. Galton (118) and Ellis (99) pointed to firstborn as being eminent, while Pearson (280) and Hansen (149) maintained that firstborn were handicapped.

The reasons for sibling differences have been much discussed. It is wellknown that dizygotic twins are less alike than monozygotic twins, but very few authors, among them Dalén (89), Hirsch (165), and Price & Hare (293), even mention the possible influence of genetics. Hirsch states that the totality of interacting genes (the genome) is very far from similar in two siblings, but because we cannot easily describe genomes we are apt to overlook this source of variation and to believe that differences are above all the result of environmental influences.

Naturally, members of the same sibship are never exposed to identical environment conditions. Demands on girls and boys differ. Two brothers can not have the same experience of playmates and friends, of school education, of occupational training and work, of place of residence, of club life, of dating and marriage. Among environmental conditions, sibling position has attracted particular attention. Veevers (398), quoting Kammeyer (195), even states that birth order is "indisputably established as a major social variable".

Greenwood and Yule (131) found the problem "in truth beset with pitfalls". The most insistent warnings come from authors who have penetrated deeply into the field: Weinberg (413), Pearson (280), Jones (189), Hsiao (172), Gregory (133), Price & Hare (293), Birtchnell (52, 53, 54, 55, 56). Gregory commented on his own extensive work, declaring that his "previously recorded significant findings with respect to ordinal position may well have been due to sampling errors". Olson (274) summarized (p 229), "One can find in the literature support for any position he may wish to take on the importance of birth order in the family for personality or any other characteristics", and added: "One must go into details of process and relationship in order to understand the importance of order in the family."

An admirable survey of methodological problems was given by Jones in 1931, on the basis of some 250 papers. He mentioned the ambiguity of the sibling concept, the dim nature of reference populations, the differential mortality among the various birth orders, the effects of maternal age and of family size. He also stressed the importance of age bar-

riers, of changes in natal interval, of diminishing birth rate, of sex ratio, of regression to the mean, and of test equipment.

Broad surveys have also been given by Hsiao (172) and others (81, 114, 249, 257, 313, 402). Most authors have published reference lists applying to special birth order topics, among them Miller (250), Schachter (318, 319) and others (71, 209, 213, 366, 400, 410). The survey of Adams (3) includes important methodologic questions: cohort problems and other demographic difficulties, researcher-induced bias, the restrictiveness of certain socialization theories and the need of sophisticated statistical controls.

2: 2. SELECTION OF REFERENCES

Hundreds of researchers have penetrated into the field of birth order: racial biologists, educators, geneticists, philosophers, physicians, psychologists, sociologists. They represent a variety of interests. Some of them openly reveal their wish to prove a cherished hypothesis. Thus, there have been passing fashions, ideas en vogue and forgotten, sensational discussion about meagre findings, much misunderstanding caused by defects in sampling and analysis.

Demographers, mathematicians, and statisticians have further promoted the study of birth order by devising methods for the analysis of samples.

Of the reports quoted in different parts of the present study, the more recent ones have been traced under the heading of BIRTH ORDER in volumes of Index medicus since 1970, while the older ones were found through lists of references or through special bibliographies. Only works written in German, English, French, Portuguese, Spanish, or the Scandinavian languages have been considered.

Abstracts containing 20 – 1200 words in telegraphic style were prepared on separate forms for each work, with letters in the margin indicating the topics dealt with in the abstract: age, sex, sibship size, diagnosis, method of selection, controls, numerical treatment, and so on.

All topics on a form were registered under corresponding headings on sheets where the special number of the form indicated the source. After assembling the forms registered under a heading, the statements in the abstracts on the particular topic were quoted in chronological order or in logical sequences. The resulting survey abounded in information, but the details were so scattered and often so inconsistent that it seemed impossible to arrive at any clear arrangement.

To this was added that methods of selection, choice of models, and numerical treatment of findings varied considerably among investigators. Even conclusions which apparently agree do not always carry conviction to the observer, as will be obvious when we come to the account of studies in alcoholism and birth order.

In this dilemma, the present writer decided to organize his review of the abstracts in accordance with the following principles:

a) One chapter (chapter 2) will refer statements regarding connections between birth order and traits.

b) One chapter (chapter 3) will refer statements regarding epidemiological circumstances which may influence the selection among birth ranks, for example the tendency of untrained parents to seek advice more often for their firstborn child.

c) One chapter (chapter 4) will refer different principles and methods which authors have used when arranging samples and analysing them numerically.

2:3. A WEALTH OF SUGGESTIVE FINDINGS

Since 1866, information regarding birth order seems to have been gathered in about 2 million persons. Obviously, researchers have felt stimulated by what they have found, even if conclusions often proved remarkably unreliable.

2:3:1. Birth order and intelligence

Though the connections between birth order and intelligence have aroused vivid interest, an inconsistent picture seems to emerge from tab 2:1, as well as from many other investigations (10, 12, 13, 72, 252, 272, 304, 354, 372, 376, 379, 386, 427). Nevertheless, the question may be considered to be solved in the 1970's. The findings of Belmont and Marolla (34) in 400,000 19-year-old males, and those of Breland (73) in 800,000 female and male participants in a National Merit Scholarship Qualification Test show a high degree of internal consistency. The decline from rank to rank within a sibship is small but signifi-

Table 2:1. Birth order and intelligence.

Author	Only child	Firstborn	Laterborn	Size of sample, comment
Mitchell 1866				1,345 mentally retarded
Galton 1874		+		99 eminent men
Ellis 1904		+		309 biographees
Fenton 1928	+			705
Guilford 1930	+			162
Hsiao 1931		none		527 pairs
Witty 1934		none		200
Tabah 1954		none		95,000
Bayer 1967			–	8,124 doctorate recipients
Adams 1968		none		1,442
Lunneborg 1968		+		5,401
Campbell 1971			–	45,000
Svensson 1972		(+)		10,000
Belmont 1973		+		400,000
Breland 1974		+		800,000

cant: about 1 % in IQ units. The average decline from sibship size to sibship size is also roughly 1 %. Thus, the members of a family of three are 2 % above the first three members of five. Onlies and twins form an exception: onlies are about 1 % lower and firstborn twins 4 % lower than the elder of two, who therefore hold the top position. Breland stated that the decline is steeper when spacing is close, even in small sibships. He advanced two hypotheses: (1) isolation from other siblings provides for closer relationships with parents and furthers development, and (2) playing an interlocutor role towards younger siblings favours development. Intellectual growth is guided by the competition of these two principles.

Zajonc, together with others, has constructed the "confluence model" (238, 429, 430) along similar lines. Total family size decides the general level of intelligence, while the stepwise growth of the family and the length of successive intervals between siblings determine the individual levels within a sibship. Training as a teacher of younger siblings raises the level. Onlies and lastborn are at a disadvantage in this respect. As a result of the competition of principles, the levels vary with time so that secondborn temporarily excel over firstborn in age groups 6 to 12 (432). The confluence model, reparametrized and provided with suitable constants, has proved applicable to a large number of studies (431). In a personal communication with the writer, Dr. Zajonc stresses that the model describes "systematic effects which incidentally are to be found almost exclusively on intellectual performance and equally exclusively on extremely large samples of population" (433). Family size and sibling interval shape the intellectual environment within the family and determine, together with teaching activities, the intellectual growth of family members. Birth order is only an indirect and imperfect expression of the crucial variables. The connection birth order/intelligence is irregular and forms U-shaped curves in some studies. This is certainly an instructive example of the connections between performance and birth order. Sibship size and sibling intervals have to be taken into consideration. Differences may be so small that even information regarding thousands of people gives no clear picture. It should be pointed out here that the conclusions from the 95,000 example in the table are built mainly on 680 pairs and 750 twins, since larger sibships were incomplete – the main material was therefore restricted to less than 3,000 cases. Among large studies quoted and used by Zajonc, may be mentioned over 109,000 Oriental Israeli, 82,000 Western Israeli, 43,000 US, 33,000 French, 23,000 Scottish, and 10,000 Swedish data.

Such numbers and mechanisms urge caution in evaluating other connections in the field.

2:3:2. Birth order and achievement/conformity

This theme is one of the oldest in the field. In some respects, it forms a counterpart of the delinquency theme that deals with destruction and maladjustment. From tab 2:2 as well as from other sources (14, 25, 29, 30, 37, 104, 108, 128, 199, 225, 230, 255, 299, 302, 312, 313, 314, 362, 368, 369, 371, 421, 428) the old impression that firstborn tend to be particularly ambitious also seems to find corroboration in investigations from later years. The more demanding the career or the social position, the larger the proportion of firstborn. Are they more apt to show the endurance, objectivity, adaptability, etc., that

Table 2:2. Birth order, achievement, conformity.

Author	Firstborn	Size of sample, comment
Galton 1874	eminent	99 eminent men
Ellis 1904	eminent	309 biographees
Campbell 1933	none	100 students
Bowerman 1947	eminent	251 biographees
Lees 1952	advancing	50 coal miners
Schachter 1963	timid dependent	600 students
Conners 1963	conforming	172 students
Singer 1964	less "machiavellian"	944 students
Cobb 1966	ambitious	192 students
Wuebben 1967	less apt to betray confidences	113 students
Diab 1968	none	200 Arab students
Bradley 1969	achieving	1,503 matched
Chemers 1970	task-oriented	350 students

are required for exceptional achievement? The studies using matched persons or R-models seem to point in this direction.

2:3:3. Birth order and character traits

Attempts to establish a connection between birth order and human fate have mainly dealt with qualities that are supposed to be favourable or detrimental: in which sibship position does one find more genius, initiative, disease, moral defects, and so on?

Adler was less concerned with external judgments than with the individual's self-appreciation, self-accusations, and feelings of inferiority. Such feelings occur in all positions, and Adler ascribed them to different reasons in different siblings. Again, such personal experiences ought to evoke different reactions, not necessarily favourable or detrimental, but characteristic. His suggestions aroused much interest among educators and psychologists as well as among laymen, and have undoubtedly stimulated research. Some examples appear in tab 2:3, and many authors have attempted to check the applicability of Adlerian ideas, or ideas of their own (1, 9, 128, 145, 159, 186, 202, 230, 264, 267, 271, 302, 321, 335, 363, 368, 370, 392, 408, 422). Results have been largely conflicting. There is possibly a tendency towards more consistent findings in firstborn.

2:3:4. Birth order and volunteering.

If firstborn were eager to conform and to aspire to eminence one would expect them to volunteer for experiments. Some small R-model samples (79, 374, 396) pointed in that direction, but larger samples (95, 405) did not. Other studies in the field (92, 228, 322, 416, 423) showed no consistent tendency.

Table 2:3. Relations of birth order and character traits (no correlation: 0).

Author	Zero corr.	Only child	Firstborn	Middle	Lastborn	Size of sample, comment
Adler 1912 Adler 1920 Adler 1930		spoiled, censuring wants an audience	dethroned, bad-mannered, conservative, greedy of power, emulating	enemy of rules envious, restless popular	degraded, childish pampered, wants an audience, prefers pleasant tasks	
Burt 1925		delinquency prone				
Stuart 1926	0					
Goodenough 1927		self-confident, aggressive, gregarious	meek, gullible, seclusive	unpopular		293 6-year olds
Campbell 1933	0					100 students matched
Stagner 1936	0					430 students
Bossard 1955, 1956				well-adjusted specialized		829 "located" in large sibships
Vuyk 1961			calm, serious, dominating, sensitive, aggressive			434
Cushna 1964			aggressive			1,255 children
Jonsson 1964		aggressive	aggressive		sensitive	222 boys
Altus 1966	0					1,300
Eisenman 1968	0 ("external-internal control")					131 students
Price 1969			serious, tidy, methodical, law-abiding, hard-working			609 pairs (paired comparison)

2:3:5. Birth order and popularity

E E Smith et al (354) found that firstborn were more often appointed leaders among 165 firemen, partly because they were less self-confident, more dependent, more skilled in social interaction, better problem solvers. Among school children and university students findings were ambiguous (97, 319, 338, 350).

2:3:6. Birth order, fear, and affiliation.

The term affiliation primarily indicates the paternal act of accepting responsibility for a person (for example an illegitimate child) or an organization (for example a subsidiary company). In psychological language, however, it is often used for the filial act of seeking acceptance as a group member.

Goodenough et al (122) described gregariousness in kindergarten children as very high in only, moderate in oldest, low in youngest children. After this, the phenomenon seems to have received little attention until Schachter (318) published his serendipitous findings about the tendencies of female students to seek company. He tried several explanations: anxiety, religion, socio-economic background, rural-urban upbringing, family size, wish to discuss, to emulate, to receive comfort or encouragement or distraction, and so on. Results were confusing until he arranged his data against ordinal position. In a fear-provoking situation, anxiety was reported by 80 % of firstborn girls, by 50 % of secondborn, 18 % of thirdborn, 0 % in later positions, $P < 0.01$. In a threatening situation, 67 % of onlies and firstborn, 35 % of laterborn wanted to be together with others. Experiments led to probabilities of randomness between .01 and .001.

The unexpected and consistent results of Schachter, built on careful experimenting and reasoning, put new life into the field of birth order research. Several authors arrived at similar conclusions (92, 96, 115, 128, 260, 296, 317, 324). Others reported inconclusive results (181, 229, 256, 267, 314, 418). MacDonald (228) even casts doubt on the registration of anxiety: firstborn are more socialized; more than twice as many laterborn failed to report at an experiment and gave suspect self-reports; when ultimately tested they were as affiliative as the rest.

The findings of Schachter no doubt point to some quality that is present mainly in older siblings and that may, under certain circumstances, express itself in the form of affiliative behaviour.

2:3:7. Birth order and neuroticism

Neuroticism as a character trait often has a vague meaning, so statements should be regarded with caution. Eysenck (103), by means of his Personality Inventory, defined it as a personality dimension: a factor of emotional instability, independent of extra introversion. The inventory, applied to college students, has given negative results regarding birth order (42, 106, 246, 377). Nycander (268), in 308 neurotic children with matched controls, found no correlation.

2:3:8. Birth order and neurosis

Neurosis as a concept covers a great many disabling states that require psychiatric care: anxiety states, depressive states, anankastic states, hysteria. Norton (266), in his classic study of 500 neurotic patients and 500 contrasts from other hospital departments, found no birth rank difference. Hysteric patients (201, 224) showed no birth order deviation, but more firstborn were reported (196) among 40 obsessive-compulsive patients than among 40 contrasts. Among 7,184 recruits (381), those with psychosomatic complaints had the same birth order distribution as the rest, but too many of the firstborn were onlies. Sheldrake et al (339) examined 4,465 arts students and reported more psychosomatic complaints and more single children than among students of the sciences, law, or medicine; the authors suggest that arts students may be more ready to communicate. Others (124, 159, 300) arrived at conflicting results.

2:3:9. Birth order and psychosis

A great many investigations look for connections between birth order and psychiatric diagnoses, such as schizophrenia or manic-depressive psychosis. Some studies built on large samples or using contrast groups (133, 233, 254) report negative results, while Patterson (279) found more middle children among 442 schizophrenics than among 500 contrasts. Of technical interest are the findings of Riess (300): more firstborn from small families, more lateborn from large families – a result that should make one suspect a "demographic illusion": young families are small, and many of their laterborn have not yet entered the sample, whereas the large families of older days have left more lateborn than earlyborn alive. When scanning literature on schizophrenia and birth order offering positive statements (22, 24, 105, 265, 301, 323, 406) or offering negative statements (64, 65, 76, 101, 102, 125, 126, 127, 136, 147, 152, 153, 187, 288, 311) one is reminded of Schooler who exclaimed (326): "Birth order effects: not here, not now!"

Hospitalization of schizophrenics is a question of epidemiology that may in itself be connected with birth order (297, 337, 355, 375), if it is considered particularly important to take care of firstborn. Some authors have found that firstborn schizophrenics tend to differ psychologically from laterborn, being more sociable, enduring, achieving (260, 267, 324; 424 – R-model method).

Similar points of view apply to depressive illness (50, 137, 138, 163, 211). Dalén found that non-familial manic conditions were connected with perinatal factors in firstborn (90).

2:3:10. Birth order and physical diseases/defects

In the dispute around the year 1900 concerning the "inferiority" of the firstborn and the "excessive fertility" of the weak, Weinberg (412) wisely refuted both ideas. Existing differences are of a much subtler kind.

Among the investigations registered in tab 2:4, particular attention should be drawn to that of Newcombe (262), which contains detailed information on a great many physical signs not mentioned in the table.

Table 2:4. Birth order and physical signs (no correlation: 0).

Author	Zero corr.	Firstborn	Laterborn	Size of sample, comment
Hsiao 1931			higher mortality	300,000 adults
Schulz 1936		birth trauma		
Penrose 1939		pyloric stenosis		
Böök 1950	0			anencephaly, 44 cases
Chen 1960		asthma		553 cases
Newcombe 1964		clubfoot	strabismus, malformations, infections	213,353 births
Newcombe 1965		neonatal death		300,000 births
Malzberg 1973		epileptics		3,906 cases
Brackenridge 1976	0			fourteen genetic systems in 421 persons

Positive findings are remarkably numerous in this field (16, 124, 232, 283, 315, 329, 365, 415, 417, 428). In other physical respects no correlation has been found (63, 64, 77, 117, 161, 162, 281, 282, 331, 422).

The interesting findings by Juret et al (191) prove that mothers with a male firstborn have a better average prognosis after an exstirpation of breast cancer with nodes in later life.

Of psychological interest is the observation by Berry (51) that firstborn tend to enter institutions for the aged nearer to their death than others do.

2:3:11. Birth order and delinquency

The topic of delinquency has been one of the roots of birth order studies since the time when Pearson tried to depict small families, and particularly firstborn children, as a threat to society. Bohannon (62) drew a boldly prejudiced picture of the unhappy development in store for only children, who "generally" had mental and physical defects and often generated friction in their social relations. Burt (75) wrote a book on the theme. On the other hand, Sletto (347) and the Gluecks (121) found more intermediate children in large matched materials. Lees et al (208) had a similar experience in 708 children and proposed a theory about expulsion of the intermediate children: they have neither the responsibilities of the oldest nor the appeal of the youngest, so they are squeezed out to play! But the renowned investigation by Slawson (346) who used 147,925 controls, as well as other control studies (17, 43, 171), arrived at negative conclusions. Conflicting findings are reported in many books and papers (21, 22, 23, 42, 44, 61, 99, 250, 259, 393). Several authors stress that child guidance clinics receive more firstborn than laterborn problem children because inexperienced parents feel anxious when raising their first child (306, 307, 340, 386, 420, 423).

2:3:12. Birth order and alcoholism

From a series of studies (23, 76, 94, 239, 240, 242, 261), one may feel that the evidence shows that lastborn run an increased risk of becoming alcoholics. Several authors have stressed the difficulties of definition (59, 166, 214, 219, 220, 269) and discussed the background (93, 193, 222, 223, 245, 292, 391, 405). Some have considered evidence feelings in this field doubtful (60, 133, 134, 135), even deceptive (45, 348). The topic will be discussed in chapter 7.

2:3:13. Birth order and smoking

With the use of an R-model, Forbes (113) found in 804 college students that smoking habits showed a steady rise from onlies over firstborn to middleborn and to lastborn. Simon (343), among 638 adult customers at a shopping centre, arrived at a similar result.

2:3:14. Birth order and homosexual reaction pattern

Most authors have failed to find any connection between birth order and homosexual behaviour/tendencies (69, 142, 192, 286, 342). Slater (345) found more lateborn men, and similar claims had been made earlier (241).

2:3:15. Retrospect

Looking back over the findings mentioned in this chapter, we may state that hundreds of researchers have tested ideas that sibling position might influence the development of human traits. Facts no doubt lend reliable support to a few of these ideas, though to a rather modest degree. Thus, it is true that elder siblings are on the average somewhat more intelligent than younger members of their sibship, but the differences are so slight as to be hardly observable. Claims that firstborn are overrepresented among well-adjusted and achieving persons must be considered proven by comparisons with the general population (72). As far as certain character traits are concerned, the significant findings of Price (292) corroborate several other reports in a convincing manner. Ultimately, the connection between certain malformations and diseases and birth order is beyond doubt. On the other hand, when we come to mental diseases, alcoholism, psychological reactions and many other conditions, we find ourselves entangled in statements which are proclaimed significant by some investigators and totally refuted by others. Such experiences threaten to put birth order research in disrepute. Since matched samples particularly often bring about the destruction of such correlations, it must be suspected that mechanisms other than birth order have caused the correlation and must be excluded before we make pronouncements on birth order effects. In the next two chapters we shall consider bias caused by epidemiologic influences or by methods of arranging the material which may make rash conclusions tempting.

Chapter 3

ENVIRONMENT AND BIRTH ORDER IN LITERATURE

In social psychology and social medicine our subject is not the individual but the mutual reactions of environment and individual: the individual in his environment (243). The birth order distribution of a sample may vary according to its epidemiologic and demographic background.

3:1. ETHNIC OR RELIGIOUS CULTURE

may be a source of error (91, 95, 125, 154, 397). A comparison of Spanish-American and Anglo-American university students showed an underrepresentation of firstborn among the former, but the statement had to be reversed when sibship size was taken into account since Spanish-American families were larger and therefore had a lower proportion of firstborn (130). In Brazil, the birth of a malformed child did not entail an end to child production but rather a doubling of family size (117).

3:2. RESIDENCE AND MIGRATION

are among the causes of bias. Sibling distribution may vary between communities (131, 132, 172). In rural districts, elder sons are more established, while younger people migrate (152, 293). In Dublin 42.8 % of men were eldest sons, against 49 % among farmers (408). In rural areas with large families one finds test results lower in late birth orders (81, 231).

3:3. SOCIO-ECONOMIC STATUS

(SES) was mentioned by Greenwood and Yule (131) as influencing the birth order pattern of social strata; Hsiao stated the same (172). High birth ranks are dominated by large families connected with low income, unskilled work and few years schooling (81), as well as with slow physical growth (334).

The pattern is further complicated by the fact that SES is an important background variable of traits like achievement motivation (252, 303) or intelligence (2). In a survey of 100,000 persons in France (430), the correlation SES IQ was +.66, but the negative correlation (−.45) between family size and IQ changed very little (to −.47) when SES was taken into consideration. Neither was there any connection between SES and the decline of IQ found in later birth orders or larger family sizes (34). When other variables are held

constant, SES differences tend to vanish. Within a total population, a rising SES does not guarantee improved intellectual performance: between 1962 and 1975, scores in Scholastic Aptitude tests among high school seniors fell from 490 to 450, according to Zajonc (430).

On the whole, these findings agree well with other results. Younger siblings seem to enjoy about the same opportunities as older members of their family, independent of SES (27, 84, 120, 130, 140, 202, 208, 304, 313). Data from psychiatric birth order studies show no clear connection with SES (101, 126, 254). In times and geographic areas with a less well developed social structure, the importance of SES tends to be more marked (8, 248, 297, 298, 397).

One epidemiological pitfall may be mentioned here: a new housing estate may contain larger families with poorer health (151), so that a sample of patients may contain many persons belonging to high birth orders. Correct numerical analysis (4: 1) will prevent unwarranted conclusions concerning SES and birth order.

3:4. FAMILY DYNAMICS

may exert a decisive influence on the formation or suppression of traits and thereby on the composition of samples.

Adjustment to family dynamics will lead to a neutral *level of adaptation* (157). A behaviour that is normal in one culture may give an impression of deviation in another.

Separation from a parent for some reason (divorce, occupation, prison, death) must of course occur at an earlier age among lateborn. Childhood bereavement has been discussed as a potential cause of depression (93, 113) and of alcoholism (90, 405). In the 1950's, Inghe in Sweden registered broken homes during childhood in 42 % maladjusted persons and in 33 % controls (178, 179).

Suggestions that the influence of family dynamics on the *whole family* should be the object of birth order study (3, 27) have been criticized on the grounds that mortality (280) and unequal risk periods of the members (189) would complicate the picture.

Studies covering considerable parts of the *life span* of propositi (245, 327, 351) make it possible to register subtle long-term effects of family dynamics and unidentified forces. Such studies avoid "the sociologic error par excellence" (308), namely, *cross-section analysis*. An asthmatic person, for example, becomes sampled as a patient because he is passing a phase of increased symptoms. Untrained observers may feel inclined to ascribe his deterioration to any distress, and his later recovery to any treatment he has happened to meet with. A *longitudinal analysis* would perhaps reveal that the trait is following its usual course of variation, including its Galtonian *regression to the mean* in due time, treatment or no treatment. Long-term registration also lessens the risk of over-simplified *typologic thinking* (165).

Family dynamics thus constitutes a highly complex sourse of influences on the formation of traits in a population. One might ask whether influences of birth order remain discernible against this motley background (57, 58). Authors who answer in the affirmative (66, 156, 158) can refer to Sears et al (336), who asked mothers of young children about training habits. Only children (n = 52) were kept track of by mothers; oldest (n = 106)

had fathers as disciplinarians and were permitted to be aggressive; middle children (n = 104) were allotted fixed jobs in the family, and nobody found much time to play with them; youngest (n = 110) were given few tasks, were expected to emulate siblings, were not permitted aggression and received many privileges ($P < .01$ for each comparison). High permissiveness of aggression against parents led to heightened aggression, not to relaxed tension.

3:5. LENGTH OF SIBLING INTERVAL

Several authors have suspected that the length of sibling interval before or after a propositus could influence his reactions and development and form a part of his epidemiologic background (2, 3, 75, 106, 189, 195, 200, 244, 295, 314, 407, 410, 421).

Until the 1960's little was known about age gaps between siblings, mainly data on averages from different periods and cultures, regardless of family size (85, 170, 172, 174, 176, 189, 358, 371, 373, 388). The short intervals of large families in old times dominated and kept average gaps low, around 2.5 years. In 1978, Belmont et al reported 4 years or more in sibling pairs (36).

Table 3:1. Sibship intervals in years. French values.

Sibship size	Authors		Mean interval
	Deville	Magaud & Henry	
2	5.2	5.0	5.1
3	3.6	3.5	4.4
	5.2	5.3	
4	2.8	2.8	3.8
	3.6	3.8	
	4.7	5.0	
5	2.4	2.3	3.3
	2.9	2.9	
	3.2	3.6	
	4.2	4.7	
6	2.2	2.1	2.9
	2.5	2.4	
	2.8	2.6	
	3.1	3.3	
	4.0	4.3	

A model based on the assumption that women produce at a uniform rate (247) does not agree with the fact that the age gap between siblings varies with birth rank (336). Practical information has been published in France by Deville in 1962 (429) and by Magaud & Henry in 1968 (intervals of 1954). The intervals in years were as shown in tab 3: 1.

Tabah & Sutter demonstrated in 1954 that sibling pairs with an interval of 2–6 years had better performance (knowledge, observation, logic reasoning) than pairs with a shorter age gap. In 1974, Breland corroborated the finding and added the hypothesis that children benefited from being instructed by parents and older siblings but also from having to instruct younger siblings. Zajonc & Markus (429) in their quantitative "confluence model", extended the reasoning: "Large spacing is beneficial to the younger and detrimental to the older sibling".

3: 6. MATERNAL AGE

There is of course a strong correlation between rising maternal age and rising order of birth, varying between .50 and .60 (283). When someone discusses birth order, how does he know that the age of the mother is not what he is really talking about? Partialling out maternal age tends to extinguish birth order correlations (91, 93, 125, 126, 164, 254, 266, 281, 282) which makes some conclusions doubtful (323, 391).

There is a connection, however, in the case of mortality (18). Laterborn siblings run a higher risk of contagion (247). In a material of 300,000 persons, mortality was higher in large families so that they became underrepresented (172). Mortality is further increased in late children of young mothers and in early children of old mothers (189, 386). The impressive material of Newcombe et al contains similar findings concerning certain malformations (262, 263, 264).

High maternal age entails advantages, too. It tends to be linked with an improved environment (247), with educational skill in the mother (303), and with higher intellectual ability in the offspring (36), probably more or less effects of selection.

There seems to be no evidence that paternal age is of importance in the birth order problem.

3: 7. MEAN SIBSHIP SIZE UNDER VARIOUS CONDITIONS

Skewness of birth order distribution in a sample is influenced by changes in sibship size in the general population with time. These mechanisms will be dealt with in chapter 7. In any case, an epidemiologic orientation is called for here.

The mean sibship size of trait-carriers in a sample is sometimes erroneously computed as the mean size of the sibships they happen to come from, that is, as $\Sigma(n_S s)/\Sigma n_S$, where s is sibship size (s = 1 . . . k) and n_S the number of propositi from size s. The correct size can be estimated by the Greenwood-Yule method (4: 2; 5: 2) as $\sum_{s=1}^{k} n_S \Big/ \sum_{s=1}^{k} (n_S/s)$. It is often impossible, however, to know whether an author has applied that correction to his ma-

Table 3:2. Estimates of family size in relation to birth cohort of child and to age 45+ of mother.

Children born in	Mean sibship size	Country	Completed family		Mean size	Country
1861 (152, 293)	6.10	England				
			1870?	(266)	5.71	England
1888 (152, 293)	4.1	England	1840-91	(174)	4.60	Estonia
1891 (152, 293)	3.5	England				
1900 (152, 293)	3.3	England				
1908 (152, 293)	3.2	England				
1918 (152, 293)	2.8	England	1920	(273)	5.79	Norway
			1950	(273)	3.11	Norway
			1966	(34)	3.25	The Netherlands

terial or not. Even a correct number can but indicate the average issue of fertile persons in the basic population. If we do not know the proportion of individuals who have never had any offspring, we can have only a vague idea of this basic population.

Terman (385) had estimated 17 % infertility and 20 % celibacy in the "stratum" to which parents of gifted children belonged. That would leave .83 x .80 = .66, or about 2/3 reproducing members of that group. In his 91 families, the average size was 2.18 (corrected). He multiplied that size by .66 and arrived at 1.44/2 = .72 as a gross reproduction rate of the parent group. The mothers and the fathers had come from families with gross reproduction rates of 1.63 and 1.28, respectively. In 1956 Penrose gave a proportion of 20 % for celibacy ("unmarried") and 10 % for infertility: in the offspring of reproducing members there were 20 % miscarriages and neonatal deaths.

It should be noted that sibship sizes pooled from different decades give scant information. Also, the definition of "family" has become increasingly vague in countries where more and more parents prefer not to marry (173). Some cohort estimates of family size appear in tab 3:2 and tab 3:3.

Poole et al (290), in their description of every other woman or man who graduated from English universities in 1960, found an average sibship size of 2.24, corrected: 1.75. Reducing for infertility and celibacy, we expect 1.16, for mortality before fertile age: 1.14, that is, .57 fertile daughter per woman. However, this value does not necessarily characterize all gifted people. Non-academic individuals with high "gifts" (not merely intelligence, but endurance, and energy, inter alia) may still have a net reproduction rate that is sufficient to maintain the production of some smaller families, also, of the type mentioned above. Akesson (7) discusses his findings among feeble-minded along similar lines. Social class may covary with sibship size (232).

Can a trait modify its own epidemiologic background, so that its basic population increases or decreases the production of trait carriers? The question is so complex that only

Table 3:3. Estimates of family size in Sweden in relation to birth cohort of mother and to age 45+of married mother, as well as to marriages of long standing (unbroken for more than 20 years).

Married mother born in	Mean size	Married mother aged 45+	Mean size	Lasting marriage contracted in	Mean size
1750 (167)	4.20	1766 (177)	4		
1800 (167)	4.70				
		1875 (295)	5.40		
		1885 (295)	5.24		
1850 (169)	4.3	1895 (295)	4.97		
		1905 (295)	4.66		
1860 (167)	4.0	1905 (88)	3.78		
1870 (168)	3.7	1915 (295)	3.81	1902 (356)	4.73
				1903 (109)	4.83
1880 (168)	3.2	1925 (295)	2.83	1905 (356)	4.45
				1908 (109)	4.25
				1910 (356)	4.04
				1912 (109)	3.45
1890 (168)	2.5	1935 (295)	2.20	1915 (356)	3.50
				1915 (357)	3.29
1900 (168)	1.88	1945 (295)	2.60	1919 (110)	2.70
1905 (169)	1.8				
1910 (168)	1.87			1940 (357)	2.36
1930 (168)	2.2	1964 (190)	1.94		
1935 (169)	2.2	(incomplete)			
1940 (168)	2.0				

some of its aspects can be touched upon here. All human traits are determined by the simultaneous interaction of environmental and genetic influences. If we imagine that the necessary genes are more or less ubiquitous, we prefer to ascribe traits to environmental forces. It a certain genetic activity impresses us as rare, we tend to call the environmental interaction "hereditary", a trait that could be controlled by family planning.

Tab 3:3 indicates what really happens. Ødegård (273) has computed the reproductivity (= marriage rate x fertility) of several diagnostic groups in relation to the reproductivity of the general population. The offspring of trait-carriers is restricted in all groups, signalling a permanent leakage from the genetic pool of the population. The leakage could be compen-

Table 3:4. Size of sibship of patients. (Values in brackets: offspring of patients.) Ødegård quotient: Relative reproduction in comparison with general population.

Diagnosis		Family size	Ødegård quotient
retarded	1929 (91)	3.76	
	1959 (147)	3.39	.315
	1959 (7, offspring)	(4.62)	
insane	1890-1929 (88, offspring)	(1.97)	
	1928 (291, women, offspring)	(1.85)	
	1928 (291, men, offspring)	(.61)	.67
schizophrenia	1888-1943 (153)	normal	
	1958 (187)	4.0	
	1959 (147)	2.87	
	1966 (127)	4.14	.528
manic depr. psych.	1966 (254)	4.60	
	1970 (153)	2.91	.76
alcoholic psychosis			.658
senile psychosis			.792
other organic psychosis			.609
other functional psychosis			.686
neurosis	1958 (213)	3.75	
	1970 (153)	2.63	
personality disorders	1967 (43)	4.03	
	1970 (153)	2.38	
epilepsy	1973 (237)	3.8	
	1975 (315)	4.10	
psychiatric cases without psychosis			.866

sated for by several mechanisms: mutation (64, 285), increased reproductivity among the relatives (117, 117a) or decreased mortality so that more of them attain fertile age. The sibship sizes reported in tab 3: 4 are of limited value, since they represent different cohorts (cf tab 3: 3) and since they merely indicate the fertility of reproducing members of the basic population: we do not know whether the proportion of reproducing members is higher or lower than normal.

Basic populations exist, however, where the sibship size of trait-carriers tends to be very markedly restricted, namely, when an undesirable trait already makes its appearance in the newborn or very small child. The next section is intended as a rough survey of this problem.

Table 3:5. Model of a (non-skewed) general population.

Sibship size	Birth order I	II	III	No.
1	a			a
2	b	b		2b
3	c	c	c	3c
Total	a+b+c	b+c	c	a+2b+3c

3: 8. RESTRICTED FAMILY SIZE

Persons suffering from malformations or other affections diagnosed soon after birth may have a background of restricted family size, if the parents have decided to have no children after the affected one. Samples of such propositi have a birth order distribution that deviates from birth orders in the general population. Several methods have been devised for estimating this effect (26, 281), but at least two of them (41, 144) started from the unwarranted assumption that the mean sibling position ought to be .5 in the basic population. Some (127, 247) stated that interruption will lead to an excess of lateborn, while others (182, 231) expected an excess of earlyborn. This conflict of statements is only apparent. Restriction makes families smaller, enhancing low ("early") ranks in the sample, and the malformation occurs in the last of them.

A consistent reduction would lead to an epidemiologic background roughly sketched by the writer in tab 3: 5 and tab 3: 6; a real situation would include skewness and cases of non-interruption. In tab 3: 5 a sample from the general population is assumed to contain a + 2b + 3c individuals, corresponding to a + b + c sibships.

If an affection with the proportion p prevents further child-bearing, a + p(b + c) get no siblings. The proportion (1 – p) = q of the remaining firstborn will be oldest in sibships of two or more. The younger sibs of bq healthy firstborn are $bq = bq^2 + bqp$, of whom bqp are affected. Another set of sib pairs appears, namely those from larger sibships where the second member is affected, here represented by a healthy firstborn group and an affected secondborn group of cqp. Among c, there now remain $cq - cqp = cq^2$ who start sibships of three, where those of rank III are $cq^2 = cq^3 + cq^2p$. Affected are q^2p of third sibs in all original sibship sizes from 3 on in tab 3: 5, thus cq^2p, dq^2p, etc. Such third sibs, together with their healthy dq^2p . . firstborn and dq^2p . . secondborn siblings, contribute to the sibships of three in tab 3: 6.

As will be seen from the column of firstborn in tab 3: 6, we still have a + b + c sibships started. The single children are more numerous than before. The sibships of two have lost some b-members and acquired a small addition of c /+ d + e . . /, with a varying net result. The birth order columns dwindle more and more with increasing ordinal number (365). The total sample is smaller than before.

The reasoning above applies to a population sample. If its skewness is known, we could insert the corresponding values, for example $c + c' + c''$ in the cells of tab 3: 5.

Table 3:6. Reproduction restricted after the birth of malformed children in the proportion p in the general population of tab 3:5. The table contains the basic population of families producing known malformed children. Non-malformed proportion: q.

Sibship size	Birth order I	II	III	No.
1	aq+ap bp cp			a + (b+c+ . .)p
2	bq cqp	bq^2+bqp cqp		2bq + 2(c+ . .)qp
3	cq^2	cq^2	cq^3+cq^2p	$3cq^2$[+3(d+e+ . .)q^2p]
Total	a+b+c	(b+c)q	cq^2	a+b(1+q)+c(1+q+q^2)

A sample of trait-carrying propositi, on the other hand, would contain only those marked by a p in the diagonal of this schematic example. Then the first column, as well as the first row, would yield p(a + b + c + . . .) propositi. In row 2 (and in column II) we have p(b + c + . .)q; in row 3 and in column III there remain p(c + . . .)q^2 propositi, and so on. The relative distribution of these propositi over birth orders is obviously the same as that of the total fertile basic population in the bottom row of tab 3:6. On the other hand, the distribution over sibship sizes in the n-column has changed considerably, giving an increased proportion of onlies, for no proportion p of the onlies in tab 3:6 could attain the value of p(a + b + c) that characterizes the onlies in the propositus sample, in relation to the total propositus population (p times the sum total of tab 3:6).

The main reason for this somewhat detailed demonstration is to show the differences between a general population, a basic population, and a sample. Even if the general population were ideally balanced as far as birth orders are concerned (tab 3:5), the trait-producing basic population (tab 3:6) would have another distribution, and the population of propositi (the diagonal of tab 3:6) yet another one. This is an illustration of the fact that the Greenwood-Yule model (4:2) has no power to describe the general population, not even its trait-producing strata, only such parts of the strata that have happened to manifest the trait by "marked" trait-carriers.

3:9. INTENTIONAL SELECTION

A sample may be biased because parents, schools, employers, etc., have created a specific basic population by means of intentional selection (395) of certain ranks. It is well known that among children referred by their parents to child guidance clinics, there are more boys (212, 287) and more firstborn (122, 190, 340, 365, 392). Parents may train their first child at home but send their laterborn to Kindergarten (189). In some cultures,

parents are more ready to give their eldest son hospital care (337, 355, 375), "only through a son the parents can aspire for heaven" (297). One school admitted only every seventh applicant, which led to a huge overrepresentation of professional fathers (327).

Selection of employees tends to entail *homogenization*, an effect that is easily overlooked (389, 390). If a certain performance is highly dependent on some specific skill and we select persons for their eminent skill, we shall find that differences in the performances of the employed depend on something else, e.g. endurance; performances cannot co-vary with homogenized skill. In a homogenized population, the negative correlation between IQ and family size tends to dwindle (376). Therefore, birth order research should avoid homogenized samples, if the homogenization restricts the variability of ranks or of the trait. The fact that we are treading on thin ice among selection mechanisms was shown by Cushna et al (87) who found 327 firstborn/325 lastborn among 1255 cases, but the elegant balance was built upon heavily skewed subgroups, cases of behaviour disorder appearing in the proportion 64/32 (apprehension of inexperienced parents), cases of congenital defect in the reverse proportion 49/84 (cf 3:8).

3:10. RESEARCHER-INDUCED BIAS

Obviously, no serious investigator wants to profit by any researcher-induced bias (3, 102, 293) in order to prove some preconceived idea of his. There seems to be no indication that a researcher would prefer or reject traits in persons with the same birth order as his own (308). All the same, he might prefer some kind of material or a certain method of selection by which he unwittingly introduces bias. The birth order literature mentioned in chapter 2 abounds with conflicting results, among which one is free to choose. In the present chapter we have hitherto considered epidemiologic backgrounds which explain why results could differ without the researcher being able to do much about it. There are also areas where he has a wider scope for optional choice: the sibling concept, the sex, and the age range decided upon when sampling the material.

3:11. DEFINITION OF THE SIBLING CONCEPT

In treating problems of sib position, a primary requirement should be to know what one is talking about when stating, for instance, that a child is number four of six. However, the definition of the sibling concept varies in a bewildering way in the literature. It serves no purpose to quote a series of authors on these matters by explicit references. Most reports do not define the concept at all. The present writer has registered some thirty authors who have taken the trouble to make a definition, and nearly all of them disagree.

Some include children of the same mother and father and call them "natural" sibs, or children of a mother older than 40 or 45 and living in a lasting marriage, or children of the same mother (half-sibs), or step-sibs, or adopted sibs, or foster sibs, or even children who happen to live in the same home (e.g. cousins), or children old enough to have passed some risk period, or stillbirths, or miscarriages. One might quote here the statements of Penrose (285) that pregnancies around 1950 ended in miscarriage in 15 % and in stillbirth

in 3 %, while neonatal death occurred in 2 % and early death in 3 %, so that every fourth biological sibling was lost.

Some exclude siblings who died before "recent years", or before the propositus was 3, or 5, or 20 years old, or who died in their old age or in infancy, or siblings who are single or illegitimate or twins or do not live with their parents, or are below or above 16 years of age, or are cross-sexed, or do not attend the same school, or who suffer from malformation or chronic illness. Authors may combine such conditions to specific patterns, for instance "no step-sibs, no mentally ill, no dead before the patient was 20".

The choice of a certain pattern may be easily understandable: one author investigates physiological variables and wants to include every pregnancy of the mother; another looks for social influences and chooses children who existed in the family during the childhood of the propositus. There is always the risk that the informant may have forgotten or never heard about siblings who died or left home before the propositus was born or when he was a small child (83).

The vagueness of the sibling concept calls for caution when we try to compare materials and results, especially materials collected in different epochs or geographical areas with high infant mortality, low expectation of life, high frequency of widowhood, divorce, or remarriage, or where many families are raised by unmarried parents.

3:12. SEX

Now and then authors stress that birth order effects may be different in *women and men* so that all results should be given for each sex separately (189, 226, 293). Few comparative investigations seem to exist in the field, however, and their outcome is not very clear (124, 362). Birth order literature contains many examples of reactions influenced by sex (2, 73, 77, 158, 196, 227, 230, 289, 304, 344, 371, 394, 425), but no significant covariation with position emerges. Investigations that are restricted to female propositi (1, 9, 14, 89, 210, 222, 299, 318, 323, 324, 418) or to male propositi (16, 43, 121, 207, 303, 337, 354, 380, 387) give little information on sex differences. Schooler registered more lastborn among hospitalized schizophrenic women, not among schizophrenic men (325).

Parents of a one-sexed family sometimes try to court fate by adding a new child. If a child of the opposite sex is born they stop childbearing. Freedman et al (116) mentioned the remarkable fact that 53 % of two-child families and 77 % of three-child families were different-sexed. Random proportions could obviously never exceed 50 % and 75 %. The over-all proportions of girls and boys remain of course undisturbed by such stratagems.

3:13. AGE RANGE

The age range of a sample, one of the truly important sources of error, has received remarkably little attention in the literature. Pearson (280) had found an overrepresentation of firstborn among adult psychotic, tuberculous, and criminal persons and sounded an alarm because he concluded that diminishing family size, with fewer lateborn, represented a threat to society. Weinberg, however, could show that infant mortality from all

causes was higher among lateborn and in large families that contributed more lateborn to the population so that fewer of them attained adult age (412); even among adult persons he found that firstborn had a better chance of survival (413).

Now and then, one encounters the idea that firstborn have run a longer period of risk. That is true within their own sibship but not in a sample of propositi as long as they are randomly distributed within the age range of the sample: there are firstborn among the youngest and among the oldest (189, 298, 332). If not, one has to perform a *correction for age* and repeat the evaluation.

Entering risk age does not favour firstborn as long as inclusion of a laterborn patient does not lead to the inclusion of affected siblings, the older of which have passed a longer risk period: the *fallacy of given sibships* (293). A similar error is committed when propositi are selected merely from sibships where all members are alive: lateborn at the upper end of the risk period may become excluded because their older siblings have died (183). An example of a particularly important kind of error is that of an epidemic disease befalling, say, 6-year-olds in an area where most parents are about 35: the sibships of such children have roughly the same age distribution, so that a certain birth rank predominates among those falling ill (18). This *fallacy of unequal birth cohorts* will receive thorough attention in chapter 7.

The *fallacy of incomplete families* is the most widely acknowledged age range error. A young mother of two may bear one, or two, or ten more children, so that a secondborn is successively a last, a middle and an early child. The concept of family size differs widely when applied to one and the same family – it may indicate the number of children born hitherto, or those below the age of 16 (as in many censuses), or those living with their parents, or those ever born to mothers now over the age of 45. A person aged 30 is always a member of a complete family, unless he gets a stepmother who is fertile. In practice, the same statement applies to any youngest child aged 15.

Completed families born to women aged 45 – 49 and living in a defined geographic area (a town, a county) form a distinct pattern of family size. The pattern is not the same in

Table 3:7. Pattern of birth orders (per mille) among children born in wedlock to mothers who married in 1950 and who lived in the same marriage twenty years later.

Duration of marriage	Birth order						Total offspring
	I	II	III	IV	V	VI+	
1st year	930	57	10	2	1	0	11,311
5th year	641	293	53	11	2	0	54,665
10th year	474	348	127	37	10	3	80,655
15th year	430	335	151	55	18	10	90,331
20th year	416	328	155	63	23	15	93,462

other areas or for contemporaneous women aged 50 – 54 or 70 – 74 (109, 111). The matter is further analysed in 3: 7 and 7: 9.

Whilst the pattern of complete sibships is a complex one, next to nothing can be said of incomplete sibships beyond the statement that a number of children are still missing, so that the proportion of firstborn will decrease, and that few young children are earlyborn, for instance 11 % in a sample of 4-year-olds (150); the rest contains lateborn or single children.

In Sweden, the offspring of certain marriage cohorts was reported (33) in birth order form. Tab 3: 7 is a rearrangement of data (31) from marriages contracted in 1950 and still existing twenty years later (marriages of long standing). The table gives a rough idea of an incomplete pattern and its changes.

The largest increase after the first year occurred in the proportion of secondborn during the first decade. Birth orders III and higher slowly attained a total proportion of about 25 %. About 8,000 children born out of wedlock or before the wedding should be added, so that the proportions in the twentieth year would increase somewhat in lower birth orders.

The per mille distribution of births in all marriage cohorts in 1969 was: 409, 389, 143, 41, 11, and 7, this time including premarital children. Obviously, the completed families of the marriage cohort of 1950 had a birth order distribution in 1969 (20th year) that was rather similar to that of all children born within or before marriage in 1969, a phenomenon that Hare & Price (152) also observed. Among other authors who have discussed the problem of incompleteness (3, 91, 127, 131, 132, 172, 189, 231, 268, 280, 295) one finds particularly those working with young children. The problem deserves attention, however, even among propositi up to the age of at least 20.

Studies dealing with *different age groups* will be summarily listed below. The list is far from complete, especially in the field of psychology.

Studies among pre-school children concern newborn (63, 275, 276, 407, 417), nursery school and child guidance cases (87, 122, 150, 200, 287, 386, 430), or general samples (107, 206, 336, 385).

Samples of school children deal with emotional attitudes (44, 208, 252, 338), with adjustment (13, 89, 248, 340, 422), and misdemeanour (23, 122, 287, 313, 386, 420), with achievement motivation and personality (8, 25, 30, 72, 186, 296, 298, 303, 314), and general questions (43, 61, 62, 75, 141, 164, 190, 232, 327, 328, 385, 403, 404).

Adolescents are particularly represented in psychological studies, often accounted for in R-models (cf ch. 1). A few papers focus on adjustment and neurotic reactions (13, 107, 120, 210), others on broad surveys of personality (1, 11, 37, 77, 128, 361, 368, 369, 370), a great many on initiative and ascendance (9, 78, 84, 95, 255, 289, 344, 371, 374, 396, 409), some on special questions (69, 113, 124, 158, 192, 194, 304, 414). After Schachter had published "The psychology of affiliation" in 1959, psychologists began to take a vivid interest in birth order problems (86, 129, 181, 312, 319, 320, 362, 418).

In adults, Galton and others studied initiative and ascendance (2, 121, 122, 159, 207), but the great bulk of samples, mostly arranged as Q-models, concerns health (90, 93, 105, 125, 126, 127, 133, 136, 137, 138, 162, 182, 265, 266, 333, 352, 391, 428, 434), alcoholism and general conditions (60, 261; 67, 197, 292; 343). The inconsistent findings of

Erlenmeyer-Kimling (101) in schizophrenia caused her to pronounce: "The birth order hypothesis has had a long test. – Perhaps it is time to call a moratorium on such studies."

3: 14. DEMOGRAPHIC CHANGES

The distribution of birth orders in a population is essentially determined by demographic changes. This fundamental epidemiologic fact is little known and seems never to have been analysed in detail. Increase or decrease of the total population, changes of fertility rate, of mortality, of average family size, and of spacing of siblings, are such variables.

In a sense, all sibships are perfectly balanced, containing one member of each birth order, provided we distribute multiple births over a corresponding number of ordinal positions, and provided we include all members ever born, even if they are now absent or dead. But as soon as we introduce age barriers or geographical limits, so that some sibships become only partly represented, we have to expect more or less serious disturbances.

The demographic situation of a newly built urbanization, with rapidly increasing cohorts of children, has already been mentioned in chapter 1 as an example of bias. the first author to point to this *bias of growing populations* was J A Cobb in 1914, who stated that firstborn become more numerous when a population increases by nativity, a statement accepted by Yule and others (18, 84). Yule seems not to have been aware that Cobb's remark invalidated fundamental principles of the Greenwood-Yule model. The theme was taken up by Hare & Price (152) in their important analysis of birth order problems. They stated that "an increase in the number of families started leads, on theory, to an overrepresentation of early birth ranks", and "increase in family size leads to a (relatively small) underrepresentation of early ranks in small families and to a (relatively large) underrepresentation of late ranks in large families", Price & Hare (293), in their catalogue of a series of bias risks, remark: "The subject matter is particularly difficult to think about clearly, even for the mathematician". Some later authors have touched upon the subject, too (3, 60, 326, 398).

In the matter of *decreasing populations*, Norton (266) underlined that most surviving representatives of the large families of bygone days are their lateborn members. Price & Hare (293) and Hare & Price (152) divided the problem into two parts: a decreasing number of families started will provide more laterborn; a decreasing number of children per family will lead to many lastborn in large sibships but somewhat more firstborn in small sibships. A few other authors have paid attention to the problem (3, 189, 326).

Varying birth rate in different periods of time may cause confusion in birth order distributions (3, 130, 152, 172, 189, 398, 408). Sletto (347) found too many lastborn among his controls (882 school children, $P < .03$). In the 1940's and 1950's, the yearly proportion of firstborn vacillated between 27 % and 43 % (27), in 1933 it was even 25 % (68). Magaud & Henry (231) call for a demographic analysis before judging proportions in a sample: among other things, one has to show that the distribution of birth orders has not varied significantly during the period examined (stationnarité de la répartition).

This leads to *cohort questions*. Ryder (310) discussed the issue in a penetrating article. History would benefit from descriptions of people born in a certain period, not only of

those living in a certain period (intercohort differentiation). Conflict does not occur between "generations" but between cohorts. A cohort is "the aggregate of individuals (within some population definition) who experienced the same event within the same time interval". Birth is a special case. Those who entered the labour force in 1934 is another case. Wars, revolutions, urbanization are further examples of events that create cohorts. He also states that birth order distribution is different in different cohorts. The question was discussed in The Lancet (204) and by Price & Hare (293) who mentioned that Kohn & Schooler had recently found, in 3091 employed males, an excess of firstborn over lastborn by 5/4, whereas Wahl had found 1/1 among 100,000 naval inductees in 1959.

Selective mortality among children of different birth orders is a possible source of skewness. The selection could take the form of stillbirths, which are more common among early and among very late sibs (182). A stillbirth will of course change the ordinal number if it is included among births. Hsiao (172) mentions that 15.7 % of "firstborn" have been preceded by a stillborn sibling. The proportions seems to differ widely in different populations, from 3 % to 20 % (189, 398, 399).

Magaud & Henry (231) warn against the fallacy of tracing more deaths among later birth orders, when the explanation is an increased mortality in large sibships; in such families even firstborn run a higher risk "lié à la dimension finale *future* de la famille".

3: 15. RETROSPECT

This chapter has surveyed literature concerning such interaction between sibling position and environment as may modify traits. Sometimes the position leads to a certain kind of environment, as when eldest sons take over the management of a farm or a firm and younger sons migrate. Sometimes the environment changes so that lateborn meet altered conditions (infections, higher SES). Sometimes a trait entails selection of a certain position, as when firstborn are sent to child guidance clinics or a malformed child remains lastborn. Common to all these cases is a birth order distribution that deviates from that of the general population. The situation is a classical one: a deviation which calls for an explanation. But the analysis is far from simple. We have to muster certain (perhaps innumerable) epidemiological circumstances and to compare our propositus sample with matched samples of persons who have not been exposed to the same circumstances. The present study exemplifies the difficulties but also a solution: people born in one decade appeared to have another birth order distribution than those born in adjacent decades. A series of conditions within different birth cohorts had to be tested until a key to the probable solution of the problem was found.

Chapter 4

TRUTH BEHIND NUMBERS: MATHEMATICAL APPROACHES IN BIRTH ORDER LITERATURE

4:1. SOME GENERAL CONSIDERATIONS

Studies reviewed in the previous chapter mainly discussed epidemiologic facts that could bias results despite a seemingly correct numerical treatment. Refined methods should not be used on weak materials (382).

It is evident that numbers give only approximate descriptions of facts, more so in biological sciences. A minute analysis of the background is necessary but not always sufficient. One can point to the *fallacy of hereditary progression* (332): when the genetic determination of a disease is marked, children may fall ill at an earlier age and with more severe symptoms than their parents, because sick parents form a selection from patients not falling ill until after marriage age, perhaps with relatively mild forms of the disease, whereas their children show a regression to the mean in respect of age at first appearance and severity of symptoms. Selection mechanisms may also *counterbalance* each other (127): a disease may befall laterborn more often, but earlyborn may receive care more often and seem overrepresented, for instance in material from child guidance clinics.

Approximate numbers. A closer study of birth order literature makes it obvious that there is no such thing as a correct mathematical method in the field. Authors use a wide variety of models but they seldom take the trouble to justify their choice. The methods described by the present writer in later chapters are certainly approximate, and the concepts used (sum, mean, deviation, etc.) should not be taken in a strictly literal sense. This limitation is not necessarily a drawback as long as one is aware of it. More rigorous methods may be more dangerous if they inspire a false sense of exactness.

Birth ranks and sibship size categories are ordinal numbers and constitute no quantities strictly suitable for use in parametric statistical tests. They belong to a ranking scale. The median, the percentiles and several other nonparametric measures can be applied, but any hypotheses seemingly proved by estimated means and standard deviations remain doubtful (341).

Despite the dangers of parametric tests, almost all authors in the field have tried to make use of them. χ^2-techniques have been critized on different grounds (197, 349, 359, 360). Modifications have been proposed (148, 197, 236) and discussed (101, 132, 355). Like two other methods (144, 345), they are built on the restriction that no skewness is present. Birtchnell (56) maintains that tests which do not include skewness are of no avail. His χ^2 tests are based on expected values derived from skewed distributions.

Distribution within sizes. When Weinberg built one of his models (tab 4: 3) he introduced an important mathematical tool: the row quotient. He divided T_X, the total num-

ber of propositi from sibships of size x, by that size: T_x/x. The quotient (in the notation used here: n_S/s) is the mean number of propositi per birth order cell of the row. Weinberg mistook that mean for the expected cell value, because he presumed that randomly sampled members of dispersed sibships ought to be evenly distributed over birth orders, just as members of total sibships are. If one added such quotients along the cells of a birth order column their total was supposed to yield the expected number of propositi belonging to the birth order in question (cf tab 4:3 and tab 4:4). The erroneous idea of an even distribution within rows (sizes) was accepted by practically all researchers after Weinberg, even by eminent mathematicians who took it for granted that members of a sibship row should have .5 as their mean position. The consequences have been fatal: a mean position that deviates significantly from .5 may have several causes - a demographic skewness, an epidemiologic skewness, a skewness among trait-carriers, or a misjudgement of nonparametric numbers. On the other hand: a mean position that does *not* deviate from .5 may indicate a significant skewness in comparison with the population mean. It is naturally impossible to draw conclusions about traits and birth order without comparing with the general population that corresponds to the sample of propositi as regards epidemiologic background. The figures in chapter 1 as well as tab 3:5 and tab 3:6 illustrate such problems.

Weinberg sampled thousands of children of tuberculous parents and of non-tuberculous parents and was able to describe birth order differences of mortality between the two groups, thereby correcting grossly erroneous conclusions of earlier investigators. His careful technique thus saved him from such pitfalls as population skewness, even if he seems never to have warned against that risk.

Distribution between sizes. Weinberg's rule. Weinberg had a keen eye for bias that could arise when a trait was more represented in some family sizes than in other sizes. He laid down a rule in 1913, that all samples dealing with birth order numbers must account for their distribution within sibship sizes. Any trait, whether it concerns physical fitness, psychological characteristics, social behaviour, or health, may be particularly frequent in some sibship sizes. Hence, we must be prepared to find that the proportions of firstborn, secondborn, etc., deviate from those in the general population, even if no difference exists between firstborn, secondborn, etc., in the rows (sizes). Table 4.1 gives a crude illustration: the risk of being marked varies *between* sibship sizes (s) so that the proportions of column totals change though the proportions *within* sizes (rows) remain the same as before. The relative number of firstborn and of lastborn has increased in the sample, but there is no overrepresentation of firstborn or lastborn.

Weinberg's statement that it is necessary to consider each size separately holds for skewed distributions as well, both for Q-samples and for R-samples. In the latter case the mechanism may be deceptively hidden, if one contents oneself with comparing firstborn and laterborn as in the bottom rows of table 4.1. One stumbles over the same conjuring trick if one compares lastborn and earlierborn. An investigator of intermediate siblings may have the bad luck to "prove" that they deviate in a characteristic way: here he would find 8:100 among 11:3, compared with 64:600 among lastborn or 100:1000 in the background sample (303, 326). A comparison within family size would prevent such mishaps.

Table 4:1. Apparent skewness because of different risks of being marked in different sibships.

Sibship size, s	Birth order I	II	III		Risk of being marked	Birth order I	II	III	
1	300				.12	36			
2	200	200			.10	20	20		
3	100	100	100		.08	8	8	8	
Total	600	300	100	1,000		64	28	8	100

In this connection, one should perhaps point to a danger of large numbers. Any biased correlation will ultimately gain significance from the square root of repeated biased experiences.

Double skewness. In cases where intermediates really deviate from first- and lastborn we can not expect much information from a measurement of mean position. Barker & Record (18) have dealt with this problem and proposed a solution.

Biased sampling of families is a regular feature of birth order research. Random selection will give a correct distribution of *members* of different birth orders and of different sibship sizes but a highly misleading picture of the distribution of *families*, which may lead to a gross overestimation of average family size. Families of six, for instance, have a sixfold chance of being represented through one of their members, in comparison with single-child families. Though the proper correction has been known since Greenwood & Yule published it in 1914, and though it has been repeated several times, e.g. in 1929 (91) and in 1958 (132), it is usual to find that authors are unacquainted with the trap.

The correction is simple. The number of sampled members, n_S, belonging to sibship size s, has to be divided by s in order to indicate the corresponding number of families of that size in the basic population which are represented in the sample. The total number of propositi Σn, divided by the total number of families, $\Sigma(n/s)$, indicates the average family size.

He who totals all members of the sibships of propositi and divides by the number of propositi will arrive at an inflated value of average family size. This explains why Galton (118) felt uneasy about the fact that each of his eminent persons, if fertile, had "only" 4.7 children aged 5–30 though they were "men with remarkably high health and energy", for he had (wrongly) estimated that the propositi themselves came from sibships containing 6.3 members on average. Ellis (99) reported discrepancies of similar size: 6.5/4.5 (after Pearson), 6.96/4.65 (Ansell), 6.8/4.7 (Sidgwick), 7/5 (a series of authors). Such miscalculations of the type $\Sigma(ns)/\Sigma n$ were believed to lend support to the theories about "degenerating mankind" around 1900. They still entice many investigators to bewail the deplorable "fecundity" of various groups of deviants.

It is a fact that eminent men come from families of one boy too many, while the sibships of eminent women contain one girl too many (99). The reason is obvious: after

Table 4:2. Ordinal numbers models.

Birth order counted from the first				Birth order counted from the last			
I				I′			
I	II			II′	I′		
I	II	III		III′	II′	I′	
I	II	III	IV	IV′	III′	II′	I′

choosing a sibship by picking out one of its members for a propositus, one must expect that the remaining children should be born according to the usual sex ratio.

4: 2. MODELS OF CALCULATION IN BIRTH ORDER RESEARCH

First-last model. The idea is quite popular that the number of firstborn should equal the number of lastborn. Obviously there has been a first one and a last one in every total sibship of two or more, completed or not. If a trait is evenly distributed over birth orders, it should appear in as many firstborn as lastborn. But that statement does not hold for a population limited by time or space. Before drawing conclusions from a sample one must know the distribution in the basic population.

Earlier half-later half model. Seemingly, less information is lost if all birth orders are included by splitting sibships into two halves than by comparing only first and last members, even if differences may become less pronounced. Both models correspond to Method C of Weinberg (see below). An investigator can analyse each sibship size separately, or all sizes lumped together, and compare with expected proportions. The crucial question is, however, to decide what proportions to expect.

Ordinal numbers model. One may sum all propositi who carry the same ordinal number, counted from firstborn, or the same ordinal number counted from the lastborn, e.g. third from the end, which equals summing diagonals. In tab 4: 2 we have counted III from the beginning, III′ from the end. Variants are of course possible, e.g. focussed on midpoint siblings or on those immediately before or after the midpoint. The model is an intrinsic part of the more comprehensive Method B of Weinberg.

In 1962, Russel Davis proposed a model that combines features of two ordinal number models. In his comments he adhered to the premise of even distribution over sibship sizes.

Weinberg models. In his work on the fertility of pathologic individuals, Weinberg (412) had reason to discuss Pearson's notions that mankind was threatened by "degeneration" through the increase of handicapped firstborn while large, healthy families disappeared. Weinberg argued that the conclusion was based on erroneous statements produced by misleading methods of calculation. Three years later, in 1913, he published his book "Die Kinder der Tuberkulosen", founded upon a huge material of persons sampled from tuberculous and non-tuberculous families. In its fourteenth chapter he described three methods

Table 4:3. Weinberg's Method B. Fictitious example, skewed.

Sibship size, s	Birth order I	II	III	IV	No. per size, n_s	Mean per cell, n_s/s
1	30				30	30
2	36	16			52	26
3	24	11	10		45	15
4	16	7	5	4	32	8
Total	106	34	15	4	159	79

of calculation, assuming a balanced rectangular distribution of members within their sibship size. He does not seem to have discussed skewness in his pioneer work in the field of birth order research.

Weinberg's Method A compares observed with expected numbers in a row that registers propositi from a certain sibship size. He stresses that one is not allowed to sum the cells of birth order columns before one has checked that the distribution of sizes is the same as in the corresponding general population (fig 4: 1). Actually, mortality is closely linked to family size and therefore higher in very late birth ranks, which is not a phenomenon connected with birth rank in the family. Later investigators have verified the foresight of Weinberg.

Weinberg's Method B inaugurated a new era of thinking in questions of sibling position. It shed light on the early findings of Galton and Havelock Ellis, and it put an end to speculations about "degeneration". A rough illustration is given in tab 4: 3. In a fictitious example of propositi, the n_s members of each row are divided by its size s and the quotient registered as n_s/s. If the propositi had been evenly distributed, each cell of the row would have contained n_s/s persons. We now construct a new table 4: 4 with n_s/s in the corre-

Table 4:4. Weinberg's Method B. Fictitious example, balanced.

Sibship size, s	Birth order I	II	III	IV	No. per size, n_s
1	30				30
2	26	26			52
3	15	15	15		45
4	8	8	8	8	32
Total	79	49	23	8	159

sponding cells and compare the columns of both tables in order to look for over- or underrepresentation. Do the column totals indicate that there are more firstborn in the observed group than we should expect if the distribution were even?

Method C compares firstborn and lastborn in a population sample with regard to the appearance of some trait. Weinberg found slightly more tuberculous children among the lastborn of healthy parents and many more among the lastborn in families where the father or (particularly) where the mother suffered from the disease. As a variant of Method C, he also compared first and last halves of all sibships (midpoint children parted into 1/2 + 1/2) in order to preserve the proportions and to use all available material. He found more deceased children in the later halves, especially in tuberculous families.

Thus, Weinberg observed a higher morbidity and mortality among laterborn in his population survey, so that more tuberculous firstborn survived and entered the hospital population. In reality, not "degeneration", but superior resistance caused their overrepresentation among sanatorium patients. Despite this experience of skewed populations, Weinberg imposed a remarkable restriction on his three models, namely, that of an even distribution of birth orders within sibships. Decade after decade, later researchers elaborated and reformulated the models, but nobody corrected the assumption of .5 as the mean position.

In 1952, Norton discovered that a method based on the idea of even distribution around .5 (the Greenwood-Yule method) led to a seemingly significant deviation but that a comparison with an independent population, matched for age, did not. In the late 1950's, the present writer constructed his first models of skewed populations and stated in a paper read before the Gothenburg Medical Association in 1959 that the apparent deviation of mean positions in a group of empirical samples (607 alcoholics, see group I in 6: 1: 3) was "an illusion caused by demographic factors" (45). Another sample of 722 patients (group II in 6: 1: 3), described by Holmgren in 1960, corroborated the finding. In 1970 - 72, Birtchnell published his large material of diagnostic groups compared with the general population and found no deviations; both materials had a skewed distribution.

The *Greenwood-Yule model* was described in December 1913. It is a mathematically detailed development of Method B, though conceived independently according to the authors. They were able to compute the mean family size in a reasonably correct way. This seems to be the first time one encounters in literature the important formula $s = \Sigma n_S/\Sigma(n_S/s)$, though the authors used other symbols.

The elaborate treatment of the B-type model linked the names of Greenwood and Yule so intimately to it that Weinberg is very seldom mentioned (63, 90, 311). In Anglo-Saxon literature the present writer has found Weinberg's name only in the original paper of Greenwood & Yule. The model has been widely accepted and critical points of view have been few. J A Cobb (83) immediately pointed to the fact that the model does not take skewed sibling distribution into account, adding that skewness "is not very easy to calculate"; he also mentioned the risk of missing information (unknown or forgotten siblings). Yule and others (127, 132) discussed the influence of incomplete sibships. Mc Keown et al (247) proposed that the model be used only for probands and sibs born within a certain period, in order to minimize changes in reproductivity and family size in the general population.

At last, Birtchnell (55) stated in 1971 that the Greenwood-Yule model must be abandoned and replaced by a procedure comparing propositi with an appropriate population sample: "positive findings of previous studies were entirely due" to "failure to compare patient samples with general population controls".

Schulz model. In 1931, Schulz proposed a modification of Method B, multiplying observed and expected numbers by s/2, thereby emphasizing the influence of large sibships (63).

Paired comparison models within families are uncommon. In same-sexed two-child families, younger sisters were considered more efficient in psychodrama (378), and in cross-sexed two-child families the younger sibling received less schooling (351). An impressive example of paired comparison is given by Price (292). Despite a biased selection and lacking standardization of parameters between 609 same-sexed sibling pairs, Price was able to demonstrate clear differences between older and younger siblings. The older ones had been less fond of cuddling, were easily trained, able to talk at a younger age, less impulsive, more tidy and law-abiding, serious and methodical, set themselves higher standards, worked harder at school, spent less time in social activities. Apart from birth order differences, Price found a rich source of information concerned with sex, future drinking habits, and so on. The spectacular results of his technique are at least partly due to the fact that it eliminates the influence of inter-pair differences.

Position index models. When Weinberg (413) had found a higher mortality before the age of 20 in the second half of sibships, he used his numbers for the construction of a sort of correlation value. This seems to have been the first attempt to relate trait to position by means of a single number. His r-value was used mainly for comparisons of different populations.

One may also relate trait to a number by calculating the mean position of trait-carriers within their sibships. In 1959, the present writer constructed such an index, $\frac{r - 1/2}{s}$, where r is the ordinal number (236) and s the size of the sibship. It was used in some publications (46, 171), but its behaviour was so remarkable that it necessitated special skewness research. In 1962, Slater published his position index, $\frac{m - 1}{n - 1}$, where m is the ordinal number and n is the size. He also gave the expression for the total variance. Assuming the general mean position to be .5, he stated that he had found significantly deviating late positions among homosexuals, psychiatric cases, and, particularly, among mongolians. Though Loxton (226) stressed that skewness in the basic population would invalidate Slater's index, it has become widely used (101, 127, 254, 391), with conflicting results.

In 1967, Berg et al (43) made an important contribution to the skewness problem when they examined birth order data that had been collected in 1947, among 37,587 boys then eleven years of age. The data showed that Slater's index continually increased with increasing family size, from .415 in two-child families to .643 in families of ten. The total mean was .493 ± .002, thereby differing from a theoretical mean of .500 in a very significant way, $P < .01$. The authors further pointed out that a population of siblings aged six months will inevitably have a Slater index of 1.0. A random sample of the boys (n = 589)

was checked at age 28 and yielded .488 ± .018, that is, differing only .005 from the original population – obviously, incomplete sibships had been too infrequent at age 11 to inflate the start value significantly. The authors found the skewness disconcerting and suspected that variations in birth rates between family sizes could explain it. They also sampled 799 boys from another population (of approved schools) and found .463 ± 013. This would have meant earlyborn siblings if the population value had been .5, but such a statement seemed doubtful in view of the population skewness. The doubts were due to "a failure to find an effective means of dealing with the distribution of birth order".

In 1972, Berg et al published data concerning 100 school-phobic in-patients, compared with 127 secondary school children, stratified for age, sex, and social class. They found Slater's index to be .594 and .519, respectively: "School phobics tend to be late in birth order when they come from families with three or more children in them". The cautious wording of the authors is certainly justified, since one must keep in mind that family size is dwindling nowadays so that large families are mainly represented by their later members. That is probably the case with the 37,587 sample above. Another example of sibship-ends was that of school children whose mothers were aged 45 or more (385) – they were mainly lateborn.

4: 3. SAMPLES FOR COMPARISON

Samples for comparison should be an integral part of the models surveyed in 4: 2, but their nature is so intricate that they deserve a section of their own.

Every description of a quality (for example birth rank) presupposes a comparison with another degree of the same quality. Both observations must be made under defined, preferably identical, circumstances in other respects.

This classic arrangement, with two of the variables free and the rest tied, cannot be realized in biologic sciences. It can be more or less approached in the planning of experiments and very imperfectly emulated in non-experimental research (395).

The crucial question of material for comparison is a central theme of the present study. Theoretically, we wish to compare the birth rank distributions in two samples: one of trait-carriers, one of non-trait-carriers, both samples having the same epidemiologic-demographic background.

In *matching* the background of the comparison sample with that of the propositus sample, it has proved difficult to combine as many as seven variables (179) into a pattern of selection criteria. One may have to choose a few variables supposed to exert a marked "disturbing" influence on the dependent variable. Among those reviewed in chapter 3 may be mentioned area of birth, age, sibship size, and sibling interval (135). Other qualifiers may be mortality, restricted family size, and selection by parents. Family dynamics is also important, but its many forms and effects do not lend themselves easily to interpretation, and they may present pitfalls – that childhood bereavement is found more often among lateborn alcoholics (222) is unavoidable, for example. Sex, family type (living with parents, in an institution, etc), marital status, occupation, and SES may in specific cases influence birth order distribution, but it is doubtful whether a regular use of these criteria as matching instruments in birth order research is justified.

Individuals in the propositus sample and individuals in the comparison sample may be matched pairwise ("social twins") so that each pair represents a specific combination of background criteria (179, 265, 266, 347). The researcher thereby ensures that the variability of a criterion is the same in both samples, but the procedure is time-consuming and tends to restrict the size of the comparison. Other researchers (44, 56, 121, 262, 320, 392) have compared with persons matched for area and age range. The latter procedure is more expedient than the social twins method.

The individuals sampled are often called *controls*, mostly under the tacit assumption that they represent some general population. A strict use of the word control would indicate that the controls have been sampled from some general population by means of random selection within specific population groups that fulfil the criteria decided upon (area, age, etc.). In each control group one has to register the distribution of birth rank and family size, perhaps also average sibling intervals in the different family types. Such data may be unavailable in official statistics. Large numbers are often needed (56, 262, 263), particularly if the age range of the propositi is wide, for each control group can represent a birth cohort covering only a few years (135, 247).

The sources of information about a general population vary. A good source is a *population survey* from about the same district as the propositus sample. The cases are traced through the Registrar's Office, or the Census Register, or some other register containing all inhabitants in the district.

Now and then, national or local statistics (*census data*) may contain the information required (340). Mostly, however, census data are suspect since they often have built-in limitations: families are incomplete; children living elsewhere, or children above a certain age are not included in the family (135, 348, 359, 408). If children of unmarried mothers are excluded, this is not always "a minor problem" (397). A comparison of a sample with a basic population and with a census population may lead to opposite conclusions (130).

A method comparing mean sibling position in a propositus sample with that in a general population (171) may be based on *official statistics* dealing with birth cohorts and with mean size of completed sibships. The method is described in chapter 7 of this study.

Some authors have used a *contrast population* (383, 384) selected by means of some specific criterion more or less independent of the trait studied. One may compare birth order distribution among psychiatric patients with birth order distribution among non-psychiatric patients (254, 266, 352) or among skilled workers, for example. As stated in chapter 1, a third sample of true controls is needed to decide whether the propositus sample, or the contrast sample, or both, deviate from the general population.

A special form of contrast is realized by the *ratio sample* (R-sample) mentioned in chapter 1 and very much used in psychological work (210, 320, 418, 425). Propositi selected by means of a common quality (students, patients, employees) are distributed according to a second quality, for example a diagnosis. The ratio of trait-carriers, or of firstborns, is registered (fig 1:6 and fig 1:7). If no control sample is added, generalizations will have a narrow scope.

Akin to the R-technique is that of *paired comparison* (204). In some way or other, sibling pairs are collected and the occurrence of one or more traits registered. The ratio among the firstborn is compared with the ratio among the secondborn for each trait (292).

In a similar way, triplets of true siblings have been studied (137, 138), though with the restriction that only one in the triplet should have developed the disease, so an underrepresentation of thirdborn resulted since their older siblings had passed a longer risk period (within-sibship effect).

More favoured than all other techniques is the one that is practically worth-less and even disastrous: the comparison with a theoretical pattern of *even distribution* around .5 as the supposed mean sibling position. Weinberg (413), despite his wide experience of real populations, did not realize the dangers of the pattern, probably because he applied his three fundamental methods to large R-samples that protected him from making mistakes but also from discovering contradictions. Greenwood & Yule (131) started the series of elaborate mathematical models (131, 144, 148, 197, 236, 309, 332) that led the majority of researchers to accept the misguiding theory of the .5-pattern.

Ultimately, we should turn our attention to the comparison sample represented by the propositi themselves, by the *basic population* and by the general population. We saw from 3: 8 that the differences between these three kinds of population may be considerable. Another example is that of tab 4: 1 where the basic population differs markedly from the propositi, despite the fact that the trait is not overrepresented in any particular birth rank. Obviously we must be cautious in pronouncements on the background population of propositi – we may be unable to decide how the basic population is composed and whether it deviates from a general population or not.

4: 4. SOME THIRTY PATTERNS OF ARRANGEMENT

It is possible to devise at least forty ways in which one can arrange a material of propositi in birth order research. The literature illustrates a lot of such patterns. Galton started the discussion in 1874 by presenting a model of six groups: onlies, other firstborn, lastborn, midpoint children, those between first and midpoint, those between last and midpoint.

Students of birth order may not always be aware of the bewildering variety of patterns to choose from. In order to make the differences easier to grasp, abbreviations are used in the following: Σ, %, r (= birth rank), III (birth rank III), s (sibship size), 3 (sibship size three), Q (quality or trait). Thus, Q%/I/5 would mean "per cent trait-carriers among firstborn in sibships of five".

As mentioned in chapter 1, there are two main types of sample. One type is sampled via the dependent variable (Q) and contains 100% trait-carriers who should be, but seldom are, compared with population controls. The other type is sampled via some independent variable (R-sample) and contains ratios of trait-carriers (Q%) in two or more subgroups where non-trait-carriers serve as a sort of contrast.

Sampling via the dependent variable (Taube). Q-samples

Q-samples without control of family size

Q 1. Σ I, Σ II, etc. Lump sums of firstborn, secondborn, etc.
Q 2. % I, % II, etc.

Q 3. As Q 1, but with onlies excluded from I.

Q 4. As Q 2, " " " " " ".

Patterns Q 1–4 are not uncommon (78, 179, 201, 210, 266, 300, 352, 386, 401).

Q 5. Broad groups, for example: onlies, eldest, intermediate, youngest. Despite warnings (83), it has become perhaps the most popular arrangement of all (68, 87, 99, 118, 122, 222, 223, 266, 355, 375, 393, 406, 420 and some twenty others). Sletto took the precaution of selecting controls, among whom he found 172 oldest and 210 youngest, $P < .03$, an instance of skewness as early as 1934.

Q 6. Firstborn-laterborn trait-carriers is also a popular arrangement (66, 84, 91, 119, 149, 261, 263, 323, 343, 350).

Q 7. Σ III – Σ non-III. A particular rank compared with all other ranks (189).

Q 8. Σ ultimate, Σ penultimate, etc. Lump sums of ranks counted from the end (55, 132, 309).

Q 9. Firstborn – lastborn, or

Q 10. earlyborn – lateborn have served as arrangements (234, 311, 323, 324, 325, 333). Rüdin in 1916 warned against skewness. Exhaustive discussion by Hare & Price (153, 293).

Q-samples with family size controlled (Weinberg's rule)

Q 11. Σ I/3, Σ II/3, Σ III/3, etc. Ranks registered for each sibship size. Many authors (e.g. 50, 136, 306, 307, 342, 354, 392, 413).

Q 12. Σ III/s – Σ non-III/s (413). A particular rank compared with all other ranks within the same sibship size.

Q 13. Oldest/s – intermediate/s – youngest/s exemplifies arrangements obeying Weinberg's rule of intrasibship size registration (27, 76, 136, 352, 379).

Q 14. Firstborn/s – laterborn/s (72, 74, 137). When family size was thus kept under control, spurious correlations vanished (222).

Q 15. Earlier half/s – later half/s (105, 153).

Q 16. Lastborn – earlierborn within sibship size (no example found).

Q 17. Many authors have used more than one arrangement. A variety of arrangements, hard to classify, has been applied by Martensen-Larsen (239, 240, 241, 242).

Positions computed

Q 18. Slater's index of 1962 is computed as $(m-1)/(n-1)$ for each propositus of rank m within sibship size n (127, 254, 300, 345, 375, 391); mean position in families and in the total sample is assumed to be .5 theoretically. An alternative notation is $(r-1/2)/s$, used by Berglin in 1960: means are compared with estimated population means (46, 171), as in chapters 5 and 7. A third notation is possible: $r/(s+1)$.

Sampling via an independent variable (Taube), R-samples

Propositi may be selected by means of a criterion more or less independent of the quality investigated: nationality, residence, enlistment in some corporation, for example. Trait-carriers and non-trait-carriers (Q and non-Q) are then distributed over birth orders (or vice versa), forming a table of 2 x n, where n corresponds to the number of birth orders chosen. The non-Q members represent a contrast group matched according to the sampling criterion. One must keep in mind that any correlation between trait and birth order might have something to do with the criterion of selection. If one should find, for example, that married men in a rural population are more often earlyborn than lateborn but more frequent among lateborn than among earlyborn, one must interpret this situation against the background that the criterion "rural" involves the fact that migration is more common among unmarried but also among lateborn (408); most non-migrants are earlyborn farmers, married or unmarried, while almost all of the few lateborn who have stayed have a family. A special interest in the field of R-samples was aroused by the writings of Adler in 1912, 1920 and 1930 in which he claimed that a certain quality Q was more common in some ranks than in others.

R-samples without control of family size

R 1. Q%/I, Q%/II, etc., in samples of students, military recruits etc. (2, 27, 71, 130, 145, 182, 227, 263, 318, 404).

R 2. Q%/oldest, Q%/intermediate, etc. (37, 186, 190, 207, 303, 336, 361, 362, 381, 408, 416, 422).

R 3. Q%/I - Q%/laterborn. Popular and dangerous pattern (1, 8, 14, 92, 96, 107, 115, 129, 255, 312, 318, 344, 415, 425, 426 and some fifteen others in the reference list).

R 4. Q%/I – Q%/lastborn (10, 11, 12, 24, 158, 414).

R 5. Q%/earlier half – Q%/later half (23, 122, 361).

R-samples with family size controlled

R 6. Q%/I/s, Q%/II/s, etc. The situation of a lastborn of three is not considered identical with that of other thirdborn or other lastborn. An important pattern that requires large materials but has proved very efficient (34, 67, 267, 303, 318, 380, 403). The pattern has helped to refute the allegations of psychopathy in onlies (372), to circumscribe the influence of birth order on personality (361) and on intelligence (432), also to elucidate the elements of happiness, a rather neglected field of research (411).

R 7. Q%/oldest/s, Q%/intermediate/s, etc (155).

R 8. Q%/I/s – Q%/laterborn/s (318).

R 9. Q%/earlier half/s – Q%/later half/s (20, 23, 28).

The many subgroups of R 7–9 make it obvious that large materials are necessary for the establishment of significant results in birth order research. Bayer et al (28) were able to show, in 46,000 propositi, that conclusions drawn from the same sample before and after size-control were completely different, as Weinberg had predicted.

Other arrangements of birth order material

The investigation of total families, suggested by Weinberg (413), has repeatedly been discussed (26, 27, 114, 231, 335). James (182) pointed to the risk of including incomplete families.

As far as the present writer can find, nobody seems to have included birth rank among criteria for selection of "social twins".

A pattern adopted by only a few authors, despite its sometimes remarkable efficiency, is that of paired comparison (cf 4: 2). Outstanding is the investigation by Price (292), but other reports have also used paired comparison to advantage (2, 206, 244, 327, 328, 335, 403). They all belong to the more interesting papers among the references.

Chapter 5

FORMULÆ USED IN THE NUMERICAL ANALYSIS OF EMPIRIC SAMPLES

5: 1. DISTRIBUTION OF SIBLINGS AND SIBSHIPS IN A BASIC POPULATION. AN ORIENTATION.

In our samples of students and of patients, the propositi were asked about sibship size, position, and year of birth, in many cases also about birth place and time span between oldest and youngest member of the sibship. The choice of trait-carriers leads to trait-producing basic populations. We shall raise the question whether sibling position is evenly distributed within our sample or not.

We also want to describe the distribution of sibships of different size within our basic populations. In this case, we must correct for the gross distortions caused by our selection procedure. Since a family of ten has a tenfold chance of becoming represented by one of its members in a sample of propositi, we have to divide by ten the number of propositi coming from that sibship size in order to reconstruct the sibship composition of the basic sibling population.

The numerical analysis of sibling material is a complicated matter. Fig 5: 1 depicts a model population; sibships with more than four members are represented by 6-child families. The model is quite crude, but the writer has often found it useful as a base for more intricate judgments. It is arranged mainly in order to form a pattern of equal samples. One or more columns constitute a sample. No regard is taken to age differences.

Table 5: 1 indicates some features of the model. The 12 rows and 12 columns of the model contain 144 individuals distributed over 58 families, so that mean family size, s, is 144/58 = 2.48 children. Only children are 12/144 = 8.3%. Families with four children are 6/58 = 10.3% of the families, single-child families 12/58 = 20.7%.

Now, it is a time-consuming task to identify and to examine a basic population, but we can extract the same information as in tab 5: 1 from a random sample of that population, represented by one single column. The n_1, n_2, n_3, etc., representatives of rows (1, 4, 3, etc.) contribute to the sum of the n-column, Σn, corresponding to the individuals in our sample. Each n_s, divided by its sibship size, forms the material of the n/s-column. The n_s-values in the n column estimate the relative distribution of individuals, whereas the n_s/s-values in the n/s-column indicate the relative distribution of families in the basic population.

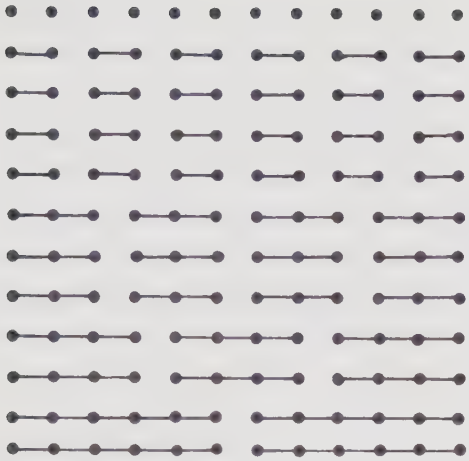


Fig 5: 1. Model of a population of 58 families. Only one type of sibship size in each row. Sibling intervals averaged.

Mean family size is then $\bar{s} = \Sigma n_s/\Sigma(n_s/s) = 12/\ 4\frac{5}{6} = 2.48$. Only children are $n_1/\Sigma n_s = 1/12 = 8.3\%$. Four-child families are $(n_4/4)/\Sigma(n_s/s = (2/4)\ /\ 4\frac{5}{6} = 10.3\%$, single-child families $(1/1)\ /\ 4\frac{5}{6} = 20.7\%$.

One should perhaps specifically caution (cf 3: 7) against constructing $\bar{s}$ as $\Sigma(n_s s)\ /\ /\ \Sigma n_s$, an error that is often committed, even in modern literature, and that would give a distorted $\bar{s}$-value of 38/12 = 3.17 in the model discussed.

A real sample is of course never composed of rigid columns like those in fig 5: 1, where the first column contains only firstborn. Instead, we expect a random selection of propositi, so that the columns exemplify the different positions within sibships and the different sibship sizes. If, on the other hand, propositi are selected from certain positions (3: 8)

Table 5:1. Distributions within the model shown in fig.5:1.

Sibship size, s	Basic population		Sample	
	number of sibships	number of individuals	n-column	n/s-column
1	12	12	1	1/1
2	24	48	4	4/2
3	12	36	3	3/3
4	6	24	2	2/4
6	4	24	2	2/6
	58	144	12	$4\frac{5}{6}$

Table 5.2. Conventional analysis of a birth order distribution. Sample: Mixed cohorts 1920-41 among 302 students. Expected column totals under the arbitrary assumption of .5 as the mean position. Significant deviation grossly missed by chi square.

Sibship size s	Birth order I	II	III	IV	V	VI	VII	VIII	IX	No. n	Cell mean n/s	Sum of positions Σp_s	Mean position $\bar{p}_s$
1	59									59	59	29.5	.5
2	50	35								85	42.5	38.75	.4559
3	33	22	18							73	24.33	31.5	.4315
4	11	7	3	7						28	7	12	.4286
5	6	8	2	4	4					24	4.8	10.4	.4333
6	1	2	2	1	4	2				12	2	6.83	.5692
7	1	2	1		1		2			7	1	3.36	.4800
8			1	1		1				3	.38	1.44	.4800
9		1	1	1		2			1	6	.67	3.00	.5
10					1	2		1		4	.40	2.30	.5750
11								1		1	.09	.68	.6818
Total	161	77	28	14	10	7	2	2	1	= 302	142.17	139.76	
Exp.	142.2	83.2	40.7	16.3	9.3			10.3		= 302			
χ^2	2.49	.46	3.96	.32	.05			.28 = 7.56 df 5, P < .20					

(mean position of the mixed sample .4628, its error .0140).

or more common in some family sizes (4: 1), we get biassed estimates of basic population values.

Table 5: 2 illustrates a conventional arrangement of data, in this case describing a group of 302 students and the relative distribution of 142.17 families in their basic population. If all positions had an equal chance among s siblings, each cell in a row of n_s persons should contain n_s/s members, so that the n/s-column and the column of firstborn ought to be identical. The n/s-column should also be the model of the column of secondborn if one excludes the onlies, and so on. One finds rather few thirdborn: 28 instead of 142.17 – 59 – 42.5 = 40.7 expected. It has been customary to apply a χ^2-test to the column totals, on the assumption of an equal distribution in each sibship row around a mean position of .5. That assumption is unwarranted, and conventional tables like tab 5: 2 should be avoided.

5: 2. COMPUTATION OF MEAN SIBSHIP SIZE IN THE BASIC POPULATION

It is believed that 5: 1 will have shown some properties of a sample that has been randomly selected from a population: Σn_s corresponds to the number of individuals, $\Sigma(n_s/s)$ to the number of families in the basic population. The n_s propositi from sibship size s represent n_s/s families in the basic population. For all such families of different size (s = 1 . . .k) we may compute the mean size by dividing all individuals by the number of all families. The writer has decided to omit the formal deduction of $\bar{s}$ and to directly state

$$\text{mean sibship size in the basic population, } \bar{s} = \sum_{s=1}^{k} (n_s) \Big/ \sum_{s=1}^{k} (n_s/s)$$

. . . . (formula 5: 1)

If the propositi are randomly distributed among birth orders and among family sizes, this Greenwood-Yule formula is applicable to any basic population. It describes the $\bar{s}$ of people born 30 years ago, with their sibships safely completed. It describes the $\bar{s}$ of a mixture of completed (full-sized) and incomplete (still enlarging) families, as in the population of today, or the $\bar{s}$ of bygone times, provided we procure a random sample, including dead people. The formula is independent of reduction due to mortality as long as losses by death occur according to the same pattern in all subgroups.

The error of $\bar{s}$ is easily computed provided we accept parametric measures. The classes consist of sizes (s), the frequency units of families (n_s/s). For all families of a certain size, the sum of squares is $s^2 \cdot n_s/s = n_s s$. For all families of all sizes in the sample, $\Sigma(n_s/s)$, the sum is $\Sigma(n_s s)$. The variance of $\bar{s}$ is then $\Sigma(n_s s)/\Sigma(n_s/s) - (\bar{s})^2$, so the error of s is the square root of $(\Sigma(n_s \cdot s)/\Sigma(n_s/s) - (\bar{s})^2)/(\Sigma(n_s/s) - 1)$.

5: 3. COMPUTATION OF MEAN SIBSHIP SIZE IN THE GENERAL POPULATION

If we want to compare our samples with the general population, we may use certain demographic data from population censuses. One type of such data is notoriously vague, namely, average sibship size. Censuses usually give the number of children living with their married parents at a certain date. This yields a mixture of incomplete and completed sibships,

mostly with the exclusion of siblings older than 16. Some censuses report the number of children born within wedlock to women who are still alive and aged 45 or over. The size of families created by unmarried parents is hardly known at all. Some demographic surveys report the number of children divided by the number of all women of fertile age. Sometimes we find reports on the number of children ever born to *mothers* who are still alive and have passed the age of 45. Some of these children do not live with their siblings. Some live with halfsibs or stepsibs. Children of dead mothers are not reported.

As long as we lack detailed information on sibship size in different birth cohorts by means of population surveys, we have to resort to demographic data describing the number of children born in wedlock and out of wedlock, as well as the proportion of premarital children who were legitimated later. A method of computation is proposed here and illustrated in 7:9 (cf tab 7:5 and fig 7:6).

If we find, in a certain year, that out of 100 liveborn children 15 are illegitimate and that 5 of these were later legitimated, we have 85 children born in 85 marriages, while 10 remain outside a married family. Many years later, we establish that each married mother has on average had s_m children born in wedlock and unmarried mothers $10s_m$ children together. If each unmarried mother has s_e extramarital children, the number of such mothers is $10s_m/s_e$. We ultimately have $85s_m + 5s_m + 10s_m = 100s_m$ children born, distributed over 85 married couples and $10s_m/s_e$ unmarried mothers: $100s_m/(85 + 10s_m/s_e)$. If we put $s_e = 1.1$, and insert it into the formula, the average sibship size is reduced to 3.3 when $s_m = 4$; to 2.67 when $s_m = 3$.

In a generalized form, we arrive at the formula for general sibship size, s_g:

$$s_g = 100\, s_m/(100 - P_e + P_e u\, s_m/s_e) \qquad \ldots\ldots \text{(formula 5:2)}$$

where
- s_g = general sibship size
- s_m = mean size of intramarital offspring of married mothers older than 45
- P_e = percentage of extramarital children two decades earlier
- u = proportion of extramarital children not legitimated
- s_e = mean size of extramarital families

5:4. COMPUTATION OF MEAN POSITION

If we range the s members of a sibship (s = 1 . . k) side by side in a close row, like cubes along a ruler (fig 5:2), we find that the member with ordinal number one will cover the space from point zero at the right end of the ruler to point 1 s, with its midpoint at .5 s. Number II covers the space from point 1 s to point 2 s, with its midpoint at 1.5 s. Thus, if the rank is r = 1 . . s, the absolute place of the member is indicated by (r − .5). A seventeenth child has its ordinal place at 16.5. The situation of a seventeenth child as a last-born may change radically if an eighteenth sibling arrives, so we want to know its (relative) position in its sibship. We may express the position as $(r - .5)\,s = p_S$ so that p_S is a point on

a limited line, namely, the line covering the total space of the sibship. The smallest value of a position is .5/s, the largest one is (s–.5)/s. Number II in fig 5: 2 has the position 1.5/7 = .2143, and IV has the position 3.5/7 = .5000.

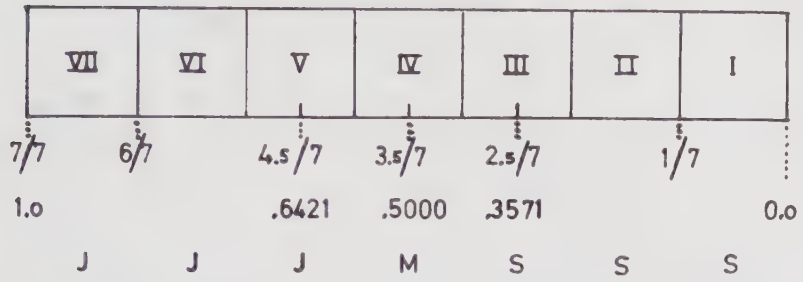


Fig 5: 2. Model of a sibship of seven. Range: 0–1. A point: 2/7. A space: 2/7 – 1/7. A place: 4.5. A position: 4.5/7.

The middle child of an uneven number of siblings should always have the position .5, and this condition must be fulfilled by any position formula. An alternative formula r/(s+1) has its range from 1/(s+1) to s/(s+1). Slater (345) has used (r–1)/(s–1) with its minimum at 0 and its maximum at 1. The present writer started to work with (r–.5)/s in the 1950's, and it is intimately connected with the constructions and results displayed in the sections that follow.

The term position may further indicate the mean of a group of positions, for example the mean position of persons belonging to the same sibship size, or to a sample containing different sizes.

The sum of positions of n_S individuals from sibship size s is $\sum_{r=1}^{s} (r_S - .5)/s$ and is conveniently computed as $\sum_{r=1}^{s} p_S = (\Sigma r_S - .5n_S)/s$, so we have the

mean position of propositi from sibship size s: $\bar{p}_S = (\Sigma r_S - .5n_S)/sn_S$

. . . . (formula 5: 3)

As an illustration, consider a sample of 37 students born 1920–29 (tab A: 1 in the Appendix). A group of 9 belonged to sibship size 3: four I:s, three II:s, two III:s, so $\Sigma p_3 = (4 \cdot 1 + 3 \cdot 2 + 2 \cdot 3 - 9/2)/3 = 3.8333$. The mean position of those nine students was 3,8333/9 = .4259, thus considerably below .5000.

If we divide the sum of all positions in a sample by the sum of all individuals, we have the

$$\text{mean position of a sample: } \bar{p}_{tot} = \sum_{s=1}^{k} \sum_{r=1}^{s} p_s \Big/ \sum_{s=1}^{k} n_s = \Sigma \frac{\Sigma r_s - .5 n_s}{s} \Big/ \Sigma n_s \qquad \text{. . . . (formula 5: 4)}$$

Among the 37 students, the sum of all positions was 16.91, so the mean position of the sample was .4569. This value is an estimate of the mean sibling position of their basic population, and it is so low that we may doubt whether the general population could be the basic population. We must postpone the answer to the question until we have ascertained the variance of the mean and estimated the corresponding mean of the general population.

5: 5. COMPUTATION OF THE STANDARD DEVIATION OF A POSITION IN A PARTICULAR SIBSHIP

In a balanced rectangular distribution within sibship size s, each position $p_s = (r - .5)/s$ has the variance

$$\text{var } p_s = (s^2 - 1)/12s^2 \qquad \text{. . . . (formula 5: 5)}$$

(One may also describe p_s as $r/(s+1)$ with a somewhat narrower variance: $(s^2 - 1)/12(s+1)^2$, or as $(r-1)/(s-1)$ with a slightly wider variance: $(s^2 - 1)/12(s-1)^2$, (345). The three expressions give very similar values. The derivation is omitted here.)

It is important to note that variances such as those mentioned above presuppose equal chances of position around the midpoint of a sibship. When we pass from the particular members of a particular sibship and turn our attention to propositi, we can not suppose that they are evenly distributed around the midpoint of their sibship size. If for some reason only the first half of sibships becomes filled, the observed variance will be correspondingly restricted, for the distribution cannot move beyond its frame and its fixed limits: 0 and 1. Such restrictions actually happen in skewed distributions, especially in small samples that fill the frame less well. In principle, each position in a random sample will have a variance that is smaller than the theoretical variance indicated by formula 5. 5.

5:6. COMPUTATION OF THE STANDARD DEVIATION OF A POSITION IN COMBINED DISTRIBUTIONS

The variance of the total distribution of positions in sibships of different size in a population can be written

$$\sigma^2_{tot} = \frac{1}{N}[n_1(\sigma^2_1 + d^2_1) + n_2(\sigma^2_2 + d^2_2) + \ldots + n_k(\sigma^2_k + d^2_k)] \quad \ldots \text{(formula 5:6)}$$

In this formula (Guilford 1950, p 579), N is the total number of individuals, n_k the individuals belonging to sibship size k, σ^2_k the variance of positions within size k, and d_k the distance from the mean position of the total distribution to the mean position of n_k individuals.

If we use the schematic population variances of formula 5:5 instead of variances derived directly from the sample, the total variance will grow larger, sometimes by as much as 50%, which makes the standard deviations increase by 22%. In a rectangular distribution, the filled and narrow space at one side of the skewed mean is in large samples the main cause of restricted variance. Thin filling up is in small samples another important cause. The schematic method compensates (and overcompensates somewhat) for that defect.

It is a matter of judgement when to use the larger deviation; in rare situations it may be safer to calculate the smaller empiric standard deviation, for example before concluding that two very similar distributions do not differ perceptibly. The schematic variances have been used in all computations built on the empiric material.

Tab 5:3 illustrates the method of schematic variances, applied to the 1930–39 cohort of the student group. With the aid of a simple electronic computer the values can be rapidly produced. In this case we arrive at a variance of .0610 instead of the .0591 we would find by a direct method. The table is worked out in great detail in order to show the application of formulae. All empiric tables have been analysed in this manner, but the results will be given only in the form of a few selected diagrams showing mean positions, standard deviations and size of sample (tables 7:9–15).

Mean sibship size will not be accounted for. About one hundred groups of patients were compared in this respect. Differences between diagnosis groups were too small to attain significance. Cohort differences, on the other hand, were quite obvious but too well-known to arouse interest. Detailed result tables dealing with positions, variances, family size, and errors were constructed but omitted. The basic information is still preserved in the tables in the Appendix.

5:7. COMPUTATION OF SIBLING INTERVALS

The term sibling interval has a precise meaning only when describing the distance in time between two particular siblings in succession: Ellen is three years older than Paul. If we apply the term in a wider sense, as when talking about the average interval in a certain family, or the usual sibling distance in a population, we shall have considerable difficulty in defining it.

Table 5:3. Student cohort 1430-39. Computation of mean sibship size and its error. Computation of the variance of each single position p_s. Computation of mean position of the total sample. Its mean error is built on schematic variances of members of sibships of different size (formula 5:6).

Sibship size	Birth order I	II	III	IV	V	VI	VII	VIII	IX	No.	No. of families	Sum of positions	Mean position	Deviation from total mean: diff.	Deviation from total mean: squared	Schematic variance	Sum of variances
s										n	n/s	Σp_s	$\bar{p}_s$	d	d^2	σ^2	$n(\sigma^2 + d^2)$
1	46									46	46	23	.5	.350	.0012	.0000	.0564
2	41	29								70	35	32	.4571	−.0079	.0001	.0625	4.3794
3	28	18	16							62	20.6667	27	.4355	−.0295	.0009	.0741	4.6482
4	8	7	3	7						25	6.25	11.625	.4650	.0000	.0000	.0781	1.9525
5	6	8	2	2	3					21	4.2	8.1	.3857	−.0793	.0063	.0800	1.8121
6		1	1	1	3	1				7	1.1667	4.4167	.6310	.1660	.0276	.0810	.7599
7		1	1				2			4	.5714	2.4286	.6072	.1422	.0202	.0816	.4073
8			1			1				2	.25	1	.5	.0350	.0012	.0820	.1665
9		1	1	1		1			1	5	.5556	2.3889	.4778	.0128	.0002	.0823	.4123
10					1	1		1		3	.3	1.75	.5833	.1183	.0140	.0825	.2895
11								1		1	.0909	.6818	.6818	.2168	.0470	.0826	.1296
										246	115.0513	114.3910					15.0137

$\bar{s}$ = 246/115.05 = 2.14

$var._s = \Sigma ns/\Sigma(n/s) - \bar{s}^2 = 749/115.05 - 4.58 = 1.93$

$\epsilon_{\bar{s}}$ = .13

p_{tot} = 114.29/246 = .4650.

$var._{p_s}$ = 15.01/246 = .0610.

ϵ_p = .0157

To begin with, are abortions and stillbirths to be included? If we are interested only in interactions between siblings, the answer is no. But what about siblings dead in infancy or raised outside their family? Is twin birth one event, or two? Since births in a family are not randomly distributed but tend to occur with increasing intervals, would it be statistically meaningful to compute a mean? Small families have longer intervals than large families. Has a single child an infinite interval?

Obviously, we can define no such thing as an average sibling distance. Yet we need some model by which we could describe a population as a series of birth columns. We want each column to represent individuals born in the same period (day, or year, or decade). The individuals should form horizontal chains of siblings from column to column. At first, the writer tried to avoid a rigid model, but it soon appeared necessary to adopt one in order to make it possible to describe connections between population characteristics and sibship characteristics. In population models, the distance between two columns should equal the average sibling distance. It therefore became necessary to collect material for a study of intervals.

The students and groups of patients who supplied data for studies of intervals were asked the size of their sibship and the year of birth of the oldest and the youngest sibship member. (Halfsiblings tend to increase and stepsiblings to decrease that time span, but no correction was attempted for such cases.) The total time span of s siblings was then divided by (s−1) in order to compute an averaged ("average") interval. For example, six siblings born between 1900 and 1912 have an averaged interval of 2.4 years, since they cover five intervals through twelve years. The averaged distances in all sibships of six were then added, the sum divided by the number of such sibships, and the quotient registered as w_6, which is the averaged interval in sibships of six in the population investigated. The value was assumed to be the same in the corresponding basic population – as a matter of fact, w_s-values seem to vary very little from population to population.

The averaged interval between all siblings born during a certain period of time, t, is henceforth called w_t. It is computed in the following way. We introduce the concept of time into fig 5: 1 and let the model depict siblings and sibships born in sequence after each other over the course of many years. We further multiply all parts of the model by some large number and let it represent a basic population. If a trait Q is randomly distributed in it, our Q-sample will have the same distribution as fig 5: 1, but propositi will form no genuine families, only shadow sibships. The n_s propositi from sibship size s represent n_s/s families. Each s-family contains (s−1) intervals, so the sum of intervals is $(s-1)n_s/s$, and the sum of their lengths is $w_s(s-1)n_s/s$. The sum total of the lengths in all sibship sizes, divided by the total number of intervals yields an estimate of

the averaged interval: $w = \Sigma[w_s(s-1)n_s/s] \,/\, \Sigma[(s-1)n_s/s]$ .... (formula 5: 7)

The intervals between sibships are already taken care of. If we add, say, mw to the numerator and m to the denominator, this does not change the outcome. In passing, we may note that the w-formula is independent of the schematic arrangement of fig 5: 1. If, for example, we stretched some intervals so that such families would occupy more space, and

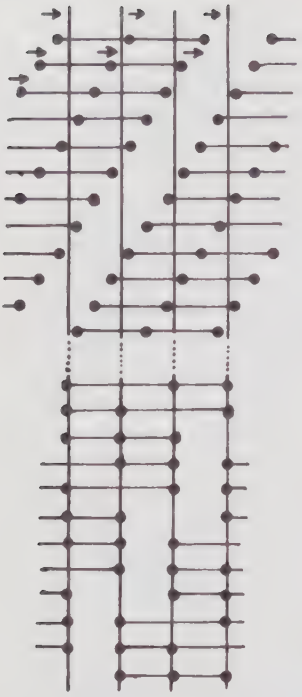


Fig 5: 3. Long average sibling intervals in sibships of three (upper part) registered at shorter average intervals of a general population (between vertical lines). Each period of registration accounts for the same number of children (lower part).

if we packed the six-child families into one row, that would not change the number of propositi or families in the w-formula, only provide it with the raw material of w_S-values it needs.

It must be kept in mind that this operational concept, the common sibling distance, is a Procrustean tool that truncates the long intervals within small families and stretches the short ones in large sibships; twins become born several years apart; only children are interspersed among other children at fixed intervals for no obvious reason except the consistency of the model. The w-value of a certain period depends mainly on the prevalent pattern of n_S-values which in its turn is derived from a mixture of sibships covering a considerable time span before and after the period.

Nevertheless the common (averaged) sibling interval, despite its shortcomings, is an important quantity since it decides the structure of the population model. The reproduction of the population takes the form of a rhythmic sowing of newborn members of sibships, each sowing rhythm a kind of "dissemination" such that all children born during a period with the length of a common sibling interval are considered to belong to the same "dissemination". If the distance happens to be 3 years, the first period, D_1, covers the ages 0—2 years. The ordinal number of the D-period multiplied by the common sibling distance marks the age at the end of the period, here 2.99 years.

In the schematic fig 5: 3, the upper version depicts births as they once occurred within sibships. In the lower part, the same births are moved to the right and accounted for at the end of their dissemination period.

Table 5:4. Averaged sibling intervals per sibship size (w_s) in the sibships of 243 students and 287 patients.

Sibship size	Students		Patients	
	No.	w_s	No.	w_s
2	85	4.72	44	3.36
3	73	4.21	50	4.29
4	28	3.18	55	3.26
5	24	3.12	42	3.66
6	12	2.95	34	2.90
7	7	2.60	24	2.42
8	3	1.86	12	2.52
9	6	2.31	12	2.30
10	4	1.97	7	2.21
11	1	2.50	3	2.27
12			1	1.75
13			1	2.30
14			2	1.95

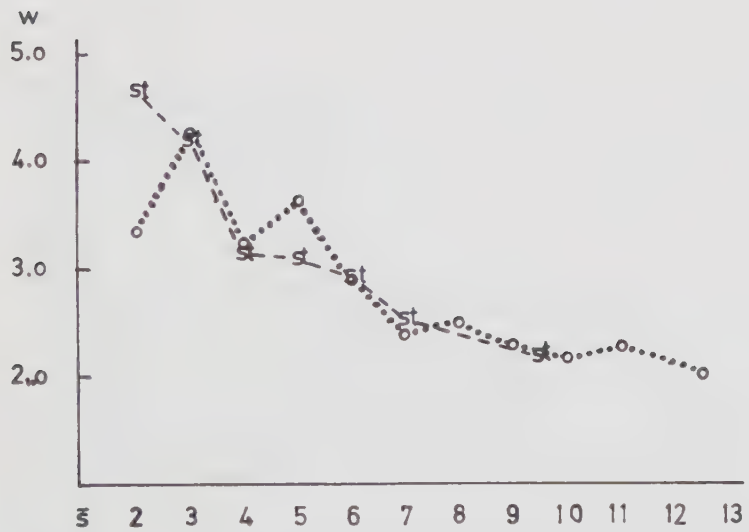


Fig 5:4. Averaged sibling intervals in years (w) in sibships of different size (s). Broken line: students. Dotted line: sociomedical cases.

Table 5:5. Estimated averaged sibling interval in the 1930-39 student cohort. Intervals per sibship size (w_S) from tab 5:4.

Sibship size s	No. n	Families n/s	Number of intervals (s-1)n/s	Length of intervals $w_S(s-1)n/s$
1	46	46	0	0
2	70	35	35	165.20
3	62	20.67	41.33	174.00
4	25	6.25	18.75	59.62
5	21	4.2	16.8	52.42
6	7	1.17	5.83	17.20
7	4	.57	3.43	8.92
8	2	.25	1.75	3.26
9	5	.56	4.44	10.26
10	3	.3	2.7	5.32
11	1	.09	.91	2.28
Total	246	115.06	130.94	498.48

averaged sibling interval = w_t = 498.48/130.94 = 3.81 years.

Though the individuals are born four years apart ($w_S = 4$) and the distance between dissseminations is only three years ($w = 3$), that does not disturb the even reproduction. In every group of twelve families, nine births occur regularly each D-period. This rhythm would establish itself even if the age parameter were changed, as long as $w_S/w = 4/3$, for instance 4.60/3.45.

The averaged intervals in the sample of 302 students were computed from 243 propositi who had siblings (column w_S in tab 5:4). The larger the sibship, the shorter the distance down to s=7. The subsequent numbers are obviously too small to give a consistent picture. For sibship sizes 8–11 the averaged distance is 2.13 years.

Among the patients, sibling distances were known in 287 cases. Their w_S values are registered to the right in tab 5:4. They show a pattern that closely resembles that of the students, except in sib pairs and in sibships of five (fig 5:4). In the patient material the w_S-values appeared to be about the same in the 1890's as in later decades. The averaged value for sizes 11–14 is 2.11 years.

Tab 5:5 illustrates the computation of an averaged interval by means of form. 5:7. The w_S-values of the students in tab 5:4, applied to the 1930–39 cohort of the students, give an average value of 3.81 years in the total cohort sample. Similar w_t-values of the socio-medical cohorts will be used in tab 7:7.

Chapter 6

THE EMPIRICAL STUDY. SAMPLING AND RESULTS

6:1. THE SAMPLING SITUATION FROM AN EPIDEMIOLOGICAL POINT OF VIEW

6:1:1. Limitations of methods and concepts

The technical report of WHO in 1960 on the epidemiology of mental disorders stresses the need to give priority to investigations into methods and concepts in epidemiological research as affecting the adequacy of both operational and clinical research, and also the need to link the conduct of special reviews to the timing and content of population censuses.

As to methods, birth order research would no doubt profit from a descriptive epidemiological approach (180), taking i.a. sex, age, family size, and sibling interval into account. At the same time, in order to avoid "la falacia ecológica" (400), we must develop descriptive instruments rather than resort to an excess of supporting hypotheses concerning a "tierra de nadie" of which we have little or no information. Among descriptive instruments, Verón mentions family demography. Another important instrument is the observer himself whose training, experience, and personality will influence the validity and reliability of descriptions.

As to concepts, their validity is notoriously doubtful in epidemiology – the "iceberg phenomenon". Thus, symptomless disease (253) remains totally hidden. Even known but mild symptoms will not necessarily bring the carrier into contact with our selection procedures (hospitalization). The same reasoning applies to social welfare cases and to alcoholics. Among those who remain excluded from sickness benefit under the National Health Insurance system because of their permanently low work capacity, there are many who suffer from an undiagnosed handicap (205). Therefore, our selected material does not represent the broad epidemiology of the disease, etc., but rather a "case fatality rate" (19).

Selection procedures are further influenced by factors of a technical or psychological nature. Production of medical in-patient care depends on the number of beds, on turnover policy, on the capacity of open-ward care and on the proportion of big consumers of care in the community (215). Demands for medical care depend not only on the severity of symptoms, but on subjective notions of health and on proneness to a risktaking style of living, including alcohol abuse and reckless driving (219). In many social problem cases disease is an important background (179, 216), as well as in persons showing a downward social mobility (220), so that medical and social concepts may be inextricably mixed.

Persons seeking social aid in Gothenburg often come from families in a characteristic situation (15, 47): long-term aid occurred among 8% of the general population and among 43% of the siblings of applicants at the social welfare offices (cumulative values).

The selection of clients of the Temperance Board is socio-economically biassed (5, 166, 214). The work capacity of the clients deteriorates rapidly, as shown by the registration at the National Health Insurance Office (48, 49, 100, 303).

The composition of the case load at the social medical offices is influenced by the varying referral policies adopted by social workers at the welfare offices. The choice of cases has varied with the general waiting time, with the urgent nature of the case, with the specialization of the physician, etc. (270).

6: 1: 2. Size of the Gothenburg population and of subgroups with social problems.

The limitations just mentioned must be remembered when we consider the quantitative relations between groups that contain the basic populations of our material, for example strata of persons with a disease that necessitates intermittent hospitalization or slowly destroys their work capacity.

The population of Gothenburg increased from about 344,000 in 1948 to about 450,000 in 1970. In 1948, about 3% were foreign citizens, in 1970 about 8%, and another 2% were Swedish citizens born abroad.

Persons who applied to the Social Welfare Board for temporary or more permanent social assistance during one year represented on average about 4% of the population, including children and other members of the families of applicants. But only 1 in 200 applicants was referred to the social medical officers: .02% of the population.

The clients of the Temperance Board and their families were often simultaneously applicants at the Social Welfare Board, but the work of the Temperance Board was of a different and more active nature. During the years 1948–53, the Board contacted each year roughly .3% of the population (95% men). In 1954, former sales restrictions concerning alcoholic beverages were abolished. Referrals almost immediately rose to 1% and more. Among the referred, about 96% were subjected to measures other than compulsory institutional treatment. Before 1954, many of the compulsory cases were examined by the social medical officer. Later the Temperance Board created its own medical organization. – Very few clients (2%) applied on their own initiative to the Board for help with their problems of euphomania. In 1954, 53% were referred for offences of drunkenness, 6% for other reasons by the Police Authorities, 24% by their family, 7% by doctors, and 8% by others.

The Public Health Board was mainly concerned with questions of hygiene (housing, food, sewage) and prevention of infectious diseases. In the 1940's and 1950's, however, the Board annually handled 400–500 cases of psychosis, alcoholism, etc., referred by the Foreign Office, the Police, the Temperance Board, and others, mainly because the Public Health Board was fairly well equipped with medical officers.

Though the different authorities regarded their cases as problems, the clients themselves did not always agree. Among the urgent cases, the Public Health Board and the Police Authorities referred psychotics creating problems in their surroundings and the Temperance Board alcoholics in need of institutional care. The Social Welfare Board and the Employment Agencies referred people who had complicated work problems with a view to vocational guidance, to training, or to pensioning.

It is obvious that the propositi in the sociomedical sample represent a heavy selection from the general population of Gothenburg. This could seem particularly promising since the population strata from which the patients stem might show characteristic properties in several respects, for example the distribution of birth order and the size of families.

The first Social Medical Office of Gothenburg was set up in 1946. The present writer, who was a certified specialist in psychiatry and head physician of a Forensic Psychiatric department, became the first social medical officer and held his office from 1946 to 1978. The administrative authority was from 1946 to 1960 the Gothenburg Board of Public Health, from 1960 to 1970 the Gothenburg Social Welfare Board and Social Service Management, from 1970 on, the Gothenburg Hospitals and Health Service Board. A social medical officer, in accordance with his instructions of 1952, had to examine clients referred by socially active authorities and by hospitals or medical officers in the city, particularly such clients as had complicated or urgent social problems. The administrative authority could further assign areas of activity that had to be given special attention: series of alcoholics, of homosexuals, and of vocational guidance cases. In the twelve years 1948–59, 2306 cases (disulfiram cases not included) were referred to the social medical officers, i.a. 37% by the Social Welfare Board, 13% by Police Authorities, 12% by the Public Health Board, 11% by the Employment Agencies, 11% by the Temperance Board, 6% by the General Hospitals, a few by the Childrens Welfare Board and others. After 1960, the Social Service Management referred nearly all cases, among whom slightly over 100 were new each year. On average, 67% of the patients were men.

6:1:3. Sampling among cases referred to the social medical officers

The sampling of sociomedical propositi started with a group of 607 male alcoholics aged 20–70 and referred by the Temperance Board in Gothenburg in 1948–54 for disulfiram treatment (*group I*). The examination lasted some 15 minutes. Routine medical data, drinking habits, earlier compulsory measures, and sibling position were entered on a standardized form. An account of the one-year results of treatment was read before the Gothenburg Medical Association in September 1959 (published in 1960 and reviewed in The Lancet). A confusing picture of birth position emerged: relatively early position in older patients, late in the youngest. A birth cohort theory seemed to offer an explanation, and in order to crossvalidate the results of the theory it was decided to broaden the material. A pupil of the writer sampled 722 patients examined 1948–59 (*group II*) from the files of the social medical officers, with the exception of alcoholics, homosexuals, and vocational guidance cases. The cases were chosen in consecutive order, provided the case histories contained appropriate information. Of the persons referred, 15–20% never appeared. Others were examined under unfavourable circumstances, such as time pressure, unwillingness to co-operate, memory disturbances. Thus, some 50% remained. Of these, some were excluded for special reasons as mentioned before. It is highly improbable, however, that any of the propositi were chosen because of the size of their sibship, and certainly none were selected because of their sibling position. In contrast to the disulfiram material, each case in group II was based on a detailed socio-medical description and an examination that had lasted one or more hours.

When the group II material was published (171) it became apparent that the numerical analysis of the problem of birth position required some knowledge of sibling intervals in sibships of different sizes. It was then decided to sample material from two sources. One source was rapidly tapped, namely that of 302 students at the Graduate School of Social Work and Public Administration in Gothenburg where the writer was for many years a lecturer and examiner (*student group*). They came from all parts of Sweden.

The other source flowed slowly: hundreds of new patients were asked when the eldest and the youngest of the s members of their sibship were born. As always, all siblings (also half- and stepsiblings), dead and alive, were included. The principles of examination were the same as in group II. The new material of patients, aged 20–70 (68% men), from the years 1960–73 was collected by the writer in 1974 (*group III*). This time, birth place was also registered in order to make it possible to refer to two kinds of general population: that of big towns, and that of other areas.

For groups I – III all identification data were delivered by the referring authority. Sibling data were obtained by the social worker or the physician and the main diagnosis determined by the social medical officer. The present writer handled all cases in group I and more than 90% of cases in group II and III.

6:1:4. The categories registered in the sociomedical material

The general sampling category is the referral of a case because of some sociomedical symptom, provided that birth rank and sibship size are known. Sub-categories are period of referral, age, sex and diagnosis.

It is important to note that the investigation primarily concerns the question whether any connection can be found between social influence of sibling position and the manifestation of certain sociomedical symptoms. Though the symptoms are registered in the form of diagnoses, they might as well be described as problems of work capacity, of family life, of intercourse with neighbours, of eufomania, etc. Background variables might have been classified in terms of disease or maladjustment of patients or family members, parental deprivation, schooling, occupation, socio-economic status, marital status, habits, style of living. It is, however, improbable that the sociomedical material could have shown that any of these categories is clearly correlated to a characteristic birth order distribution. In the diagnosis groups, the standard deviations of birth cohorts were far too large (.04 or more) to permit any conclusions. Neither did the material as a whole, nor subgroups of 400–600 persons, differ significantly from an expected (skewed) cohort distribution (cf chapter 7). Actual differences are mostly so small that huge materials would be needed in order to have their significance tested.

Two further remarks are perhaps called for at this point. The investigation concerns the sociomedical influence of birth position and the methods of forming reliable conclusions regarding this influence. The investigation does not concern the sociomedical influence of other background factors. Its aim is not to prove the nature of those factors which are mainly responsible for a certain sociomedical effect.

Secondly, the skewed birth order distributions of the sociomedical material were practically identical with the expected skewed distributions of the general population cohorts. Although it would have been technically possible to account for the omitted cases in terms of sex and age, no such account was attempted. Naturally, it is theoretically con-

ceivable that the various causes of omission might be connected with birth rank. In this case, however, one must postulate that the omission has had a normalizing effect on birth orders in the remaining case-load of 2,000 persons, which seems far-fetched.

6:1:5. Material for comparison

One propositus sample may contain a marked excess of certain sibling positions (more lastborn than firstborn, for example) and yet show no overrepresentation. In another sample a practically even distribution of earlyborn and lateborn may indicate a marked overrepresentation. The concept of overrepresentation is inextricably tied to the condition supposed to be represented, in this case to the birth order distribution of the appropriate general population.

Birtchnell (56) sampled 6795 patients, suffering from depression, from other psychosis or neurosis, from alcoholism or personality disorder. He compared them with 3425 controls from the local general population. The birth order distributions of the propositus groups did not deviate significantly from that of age-matched controls. On the other hand, the population values differed clearly ($P < .01$) from a balanced distribution and they changed ($P < .001$) from birth cohort to birth cohort; the mean position of the cohorts varied (55) over a fairly modest range, from about .51 to about .52.

The present writer decided to desist from sampling individual controls. The main reason for this decision was the experience that available population statistics provide a suitable material for comparison. This material takes the form of a population model (described in chapter 7) where mean positions move over a wider range, from about .49 to about .54. The mean positions of the sociomedical samples move over the same range in close correspondence with the values predicted by the empirical population model.

6:2. THE STUDENTS: SEX, DECADE OF BIRTH, BIRTHPLACE

Tab 6:1 shows the distribution of sex and decade of birth of the students. Their birth places were spread over all the Swedish counties save one. Eleven were born abroad, 13% came from Gothenburg (33 women, 7 men), 42% from other towns (71 women, 56 men), 45% from country parishes (70 women, 65 men).

Table 6:1. Sex and decade of birth of 302 students.

Decade of birth	Women		Men	
	Number	%	Number	%
1920-29	16	9.2	21	16.4
1930-39	139	79.9	107	83.6
1940/41	19	10.9	0	0.0
Total	174	100.0	128	100.0

Table 6:2. Sex and decade of birth of 2,000 sociomedical cases.

Decade of birth	Women			Men			
	group II	group III	%	group I	group II	group III	%
1880-89	23	–	4.7	–	10	–	.7
1890-99	57	19	15.6	71	36	24	8.7
1900-09	71	62	27.3	173	83	84	22.5
1910-19	58	48	21.8	225	114	92	28.5
1920-29	53	36	18.3	138	137	94	24.4
1930-39	15	23	7.8	–	65	87	10.0
1940-49	–	22	4.5	–	–	80	5.3
Total	277	210	100.0	607	445	461	100.1

6:3. THE PATIENTS: SEX, DECADE OF BIRTH, DIAGNOSIS

The members of group I were men, and so were 224 of the 243 alcoholics in group III. In the remaining material the proportion women/men was slightly over 40:60. The distribution of sex and decade of birth appears in tab 6:2.

Mean birth date for women was 1912.5, for men 1916.9. The difference which is very significant, 4.4 ± .73 , is mainly connected with "non-schizophrenic psychoses" (senile and other) among older women, as well as with character disturbances and encephalopathy among younger men. In tab 6:3 group I and the alcoholics of group III have been left out in order to make distributions of diagnosis groups comparable.

6:4. THE BASIC POPULATION

Before entering upon the numerical analysis of data in the samples of probands, we must turn our attention to the population represented by the probands, i e the basic population.

When working with given samples of probands, for instance students, or schizophrenics, we are dealing with certain strata of the general population that produce students, or schizophrenics. We must be prepared to find that such strata show characteristic distributions of fertility, education, marital status, occupation, and other socioeconomic variables discussed by Lindegård (218) in a population survey of 2117 men aged 43.

The term basic population may have several definitions. We might apply it to the selection-prone trait-carriers from whom probands were chosen. We may also prefer to use the expression for larger groups where many persons lack the trait but among whom trait-carriers are more frequent than elsewhere (cf 3. 8 and 4. 3). Sometimes the connection is quite close, as when confession of faith is linked to a national minority group, or an occu-

Table 6:3. Percentage of diagnosis groups among 1,150 patients.

Diagnosis group	Women (N = 468)	Men (N = 682)
character disturbance	12.8	18.3
oligophrenia	13.5	11.1
encephalopathy	4.3	10.9
neurosis	18.2	18.6
schizophrenia	13.9	14.1
other psychosis	22.9	11.0
somatic main diagnosis	14.5	16.0
	100.1	100.0

pation to some kind of formal education. Other interdependent principles of selection are occupation/sex, or apprenticeship/age. Two or more principles may also be more incidentally mixed, for example disease, hospital facilities, and geographic area. When planning the choice of a target population, one may intentionally try to compensate for such complications by governing the procedure of selection. In a material that is selected beforehand (a school class; a case load of patients), however, we arrive somewhat post festum at a basic population that may be rather specialized because of selection criteria that restrict each another.

A special form of biassed representation arises from the fact that propositi come from fertile strata in the previous generation. Their own fertility per individual will probably not be the same as that of their parents, but regress towards a mean. Genetically, propositi represent not only their parents, but a still wider stratum.

One of the aims of this study is to show that we should also consider birth cohorts as basic populations when judging position of propositi within their sibships.

6:5. THE STUDENT SAMPLE: RESULTS

Tab 5:2 describes the distribution of the sample of 302 students over sibship sizes 1–11 and birth order numbers I–IX. The table may serve as a paradigm of conventional arrangement.

A cursory inspection shows that earlyborn are numerous in sizes 2–5, while the largest sizes are represented mainly by a few lateborn: large sibships are hardly started any more. The n-column looks like a disseminate, the n/s-column like a distribution of sibships (families with children) in the basic population (cf tab 5:1). The conventional method of calculation presupposes that, in principle, all cells in a row of the table should be equally

Table 6:4. Mean position and mean sibship size in cohorts of the student sample and the total sociomedical sample.

Sample	Σn	$\Sigma(n/s)$	$\Sigma\Sigma p_s$	$\bar{p}$	Σvar_{p_s}	$\epsilon\bar{p}$	$\bar{s}$	$\epsilon\bar{s}$
Students:								
1920-29	37	16.66	16.91	.4569	2.58	.0433	2.22	.43
1930-39	246	115.06	114.40	.4650	13.20	.0157	2.14	.13
1940/41	19	10.46	8.46	.4454	1.27	.0609	1.82	.35
Patients:								
1880-89	33	10.83	17.13	.5190	3.30	.0550	3.05	.77
1890-99	207	58.51	100.47	.4854	16.05	.0194	3.54	.38
1900-09	473	124.55	236.03	.4990	35.35	.0126	3.80	.24
1910-19	537	169.07	283.19	.5274	38.79	.0116	3.18	.19
1920-29	458	172.57	250.75	.5459	30.49	.0121	2.65	.17
1930-39	190	78.06	95.84	.5044	12.97	.0191	2.43	.21
1940-49	102	38.86	51.65	.5064	7.38	.0266	2.62	.26

filled, namely by n/s siblings per cell, and that each table column should equal its corresponding part of the n/s-column, so that the totals should be comparable by for example a χ^2 test. Such calculations are not justified, however, for equal distribution over a row is a fiction. Even in the small example presented in tab 5:2 an important phenomenon appears: skewness in different directions. Isolated birth cohorts are often skewed in opposite directions. They can easily be selected so as to create a total sample looking deceptively balanced, or biassed in any direction. Such effects are particularly fallacious when they occur in samples that have been selected under careful preservation of randomness.

Tab 5:3 accounts for the 1930–39 cohort among the students. It is a decided technical improvement on tab 5:2 with its conventional mixture of different cohorts, some small, some large. Mean sibship size in this student cohort is 2.14, with an error of .13. Mean position is .4650 with an error of .0157. Obviously, since $(.5 - .4650)\ .0157 = 2.23$, the risk of random deviation from .5 is less than 3%. We can state with some confidence that earlyborn are more numerous than lateborn in this subsample, but not that they are overrepresented. In any case, the statement is of no practical interest as long as we know nothing about the real population mean in the 1930's. We shall see later that we have reason to expect a mean position of .4850 or thereabouts in the population, so the difference is only 1.58 times its mean error.

If we perform a similar computation in tab 5:2, we find that the position mean of .4628 has an error of .0140, so the probability of a random deviation from .5 would be less than 1%, considerably less than the χ^2-method indicated.

Tables A: 1–3 in the Appendix register the three student cohorts. The mean position of the 1920–29 cohort is .4569 with a mean error of .0433, and the mean position of the 1940/41 cohort is .4454 with an error of .0609 (tab 6:4).

It is the intention of the writer to show that we have reason to believe that members of the 1920–29 cohort of the general population have a sibling position mean in the neighbourhood of .54. The difference .54 .4569 is 1.92 times its mean error of .0433, so this time we may state with more confidence that earlyborn are not only more numerous but also really overrepresented in the student group. In passing, we should note that $\Sigma(n/s)$ is 16.7 compared with $\Sigma(I) = 19$, not very different. Also, $\Sigma(n/s) - \Sigma(n_1) = 8.7$ and $\Sigma(II) = 8$, almost alike. Thus, a conventional calculation would miss the significant difference completely.

6:6. THE SOCIOMEDICAL SAMPLES: BIRTH COHORT DISTRIBUTION

The samples of 607 + 722 + 671 = 2,000 patients were divided into subgroups according to sex and diagnosis. The total sample, the two sex groups, the three sampling groups, the eight diagnosis groups and the "non-alcoholics" group were ultimately divided into age groups according to decade of birth.

The distributions of 29 birth cohort groups are displayed in tables A: 4–32 in the Appendix. They can be combined into larger groups when needed. Thus, birth cohort distributions of women (tab A: 20–26) and of the total material of patients (tab A: 4–19) enable the computation of male distributions.

Among 140 samples and subsamples many were as small as 50 or less, and it was considered useless to work with them. This was particularly the case with samples combining diagnosis and decade. When subgroups of neurotics (n=212) or schizophrenics (n=161) were divided into decade parts, their mean positions became rather uninteresting because of errors as large as .04 or more. A combined group of alcoholics (607 + 243) yielded decade samples large enough for evaluation.

The numerical analysis led to the preparation of a table registering pertinent values from 105 samples and subsamples. For reasons of economy, this large table was omitted. Tab 6:4 demonstrates the principles of registration, exemplified by the student sample and the total sociomedical sample. Further results are reported graphically by means of fig 7: 8 -16. They show the mean position and its standard deviation, as well as the number of patients within each cohort of the total sociomedical sample and six of its larger subgroups.

6: 7. THE SOCIOMEDICAL SAMPLES: MEAN SIBLING POSITION

The numerical analysis demonstrates that mean sibling position undergoes considerable change from decade to decade in the sociomedical cases. Mean position moves from earlyborn in the 1890's to lateborn in the 1920's ($P < .01$) and then back again in the 1930's. The phenomenon returns in the large subsamples: in group I ($P < .10$), in group III ($P < .02$), in women (one-tailed, $P < .20$), in men ($P < .005$), even in a small group of 243 alcoholics ($P < .02$), also from 1900 to 1920 in group II ($P < .10$).

We get the impression that skewness of sibling position is mainly governed by one or more mechanisms closely connected with birth time. Chapter 7 will describe how we can try to trace such influences.

6: 8. THE SOCIOMEDICAL SAMPLES: MEAN SIBSHIP SIZE

From chapter 7 we find that changing sibship size in the general population is one of the mechanisms we are looking for. As far as the propositus material is concerned, however, it has not been the aim of this investigation to analyse sibship size of the samples – they are mostly too small for that. The total sample no doubt shows a general decrease of sibship size since 1900, attaining significance at the 5% level from the first to the second, and from the second to the third decade of the century, but these are well-known demographic facts. Notwithstanding, the age patterns of family size may make it easier to understand that similar age patterns of sibling position exist, as the next chapter intends to show.

Chapter 7

MODELS DESCRIBING THE REGULAR SKEWNESS OF BIRTH ORDER DISTRIBUTION PREVALENT IN GENERAL POPULATIONS

Among 607 alcoholics (group I) examined in the years 1948–54, older patients were remarkably often earlyborn, younger patients lateborn in their sibship. Models built on population statistics gave a picture that closely resembled the empirical distribution. A logical analysis was the sole basis for the choice of models. They were not adapted to suit the material. Their predictions were borne out by some 1400 later findings.

7: 1. MODEL OF A SIBSHIP

The number of children in a family, including halfsibs and stepsibs, may vary from 1 to over 20. In this connection we denote all such families as sibships, and we divide a sibship (a family) into an older part of Seniors (S) and an equally large younger part of Juniors (J) (fig 5: 2). When the number (s) of siblings is uneven, there also exists one middle child, the Median (M). The birth order (rank) of a Median is $r = (s+1)/2$, for example an only child; number II of 3; number V of 9.

According to 5: 4, a sibship member with rank r occupies the relative position of $p_S = (r-.5)/s$. Each member occupies the relative space (proportion) of 1/s, for example between point 5/s and point 6/s.

7: 2. MODEL OF A POPULATION

Let us first study the model of some sort of stable general population in fig 7: 1. It flows like a stream with an even breadth from left to right, from decade to decade, from the newborn to the centenarians.

Those who have emigrated or died still exist as cohort members so that we find, in a certain year, as many 56-year-olds as 13-year-olds. And many years later there are still as many 13-year-olds who have succeeded earlier groups. Each birth cohort comes marching as if arranged on a line over the whole breadth of the population. Obviously this picture is unrealistic. Yet evaluations of birth order distribution sometimes seem to start from tacit assumptions like this, and it will be wise to introduce realistic corrections step by step.

We have to consider a population of sibships, not a population composed of random births. After a line (column) of children born within a certain month, a new line of siblings will not arrive before a considerable time has elapsed, in some sibships perhaps one year, in other sibships many years. Time span between births differs from family type to

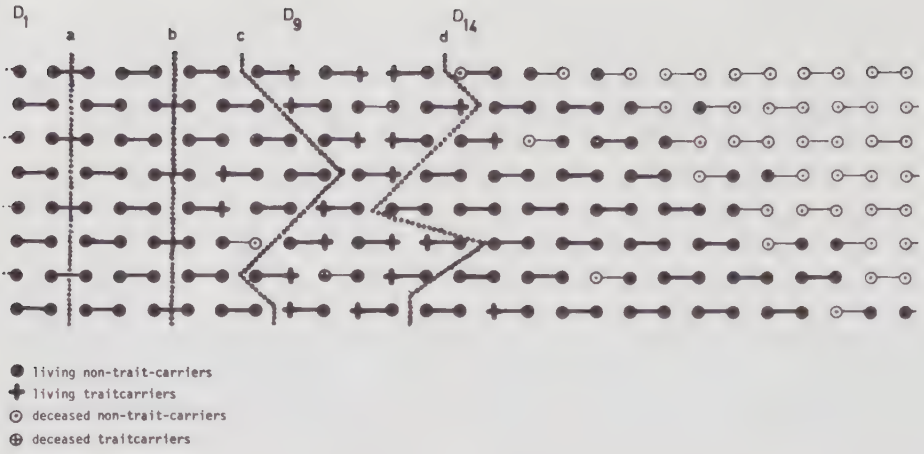


Fig 7: 1. Model of a stable population containing trait-carriers. D: birth cohort covering about 3.5 years (a disseminate). a and b: age limits. c and d: limits of a sample containing trait-carriers belonging to birth cohorts $D_9 - D_{14}$.

family type, as was shown in 5: 7. It would be practically impossible, however, to consider all these different values in our calculations, so we construct an averaged interval between all sibs of a sample.

This averaged interval is a distortion in itself, derived from a mixture of patterns. Some families with a high fertility may have a new child every year, some have children ten years apart. Single children represent an extremely long interval to the "next" sibling. We are simply forced to include those onlies who were born during a certain averaged period of sibling interval.

In this way, we have formed our population into a pattern of waves following each other. Members of such a wave have practically no siblings in their own wave, but many of them have in neighbouring waves. We need a name for such waves. To call them generations would be misleading. In a sense, they are cohorts, that is, literally, germs growing in the same limited garden. The present writer proposes the term *disseminate*, *D*, indicating all individuals in a population who are born during a time span as wide as the averaged sibling interval (w) at that time. The space of a disseminate is therefore w_i when it is centred around the moment i. We may choose i at will, and nothing stops us from working with disseminates telescoped into each other if need be. We have to work with mixed disseminates if a population represents more than one basic population because of immigration. In a sample, a disseminate takes the form of a dissemination column, a D-column. The N members of a sample, born at a constant rate during t years, are distributed over t/w disseminates, so that each dissemination column contains Nw/t members, all of them belonging to different sibships. Each member of the D-column represents one row in fig

7: 1. A sample covering t years of birth, and containing N_t members of t/w dissemination columns with a mean interval of w_t years has the

$$\text{number of rows passing a D-column} = \frac{N_t w_t}{t} \qquad \ldots . \text{(formula 7: 1)}$$

7: 3. EFFECTS OF DIVISION

In our population models we often have reason to arrange the D-columns systematically so that they form a continuum without overlapping or gaps. Fig 7: 1 depicts 27 disseminates of members of sib pairs, that is, up to about 100 years of age. Each D, save the first one, contains as many S as J. The vertical lines *a* and *b* divide the population according to age, for example school children between ages seven and seventeen. There is no overrepresentation of S among those who enter school nor among those who leave school. The total population between *a* and *b* is evenly divided into S and J. If we move *b* one step to the right, in order to include males entering military service, this makes no difference since girls and boys will as a rule be randomly distributed. Neither does it matter whether we draw a line through the middle of a D-column or between columns.

A more complicated kind of division line develops when we select those members of a population who are carriers of a characteristic trait. Such propositi are represented by crosses in the figure. Lines *c* and *d* are drawn so as to separate propositi of certain ages, together with their siblings. Some trait-carriers have been too young or too old to be included, namely, those below D_9 or above D_{14}. Particularly numerous are propositi in D_{11} and D_{12}, so the division lines take a rather irregular course. They all pass between sibships, so such samples have a perfect balance of S and J. If propositi themselves are not overrepresented at either end of their sibships, their sibs must be evenly distributed, too. The same reasoning applies to trait-carriers outside the *c-d* sample, but we must make an exception for the youngest part of the population that always contains a J excess, as will be shown in 7: 4. If propositi occur in these ages, they are apt to contain a corresponding excess, whilst their siblings show the opposite excess. (Comment: Marking any J in a sibship introduces an unmarked S. Non-trait-carriers, too, are more often J in the youngest disseminates, but they form no propositus sample of their own.) Thus, propositi *and* their sibs (living and dead) constitute a perfect balance of J=S, but sibs *of* young propositi tend to contain an excess of S. We catch a glimpse of the reason in fig 7: 1. Below line *a* there are four J ends and four balanced sibships.

Above line *b*, on the other hand, we find in ages 18–100 that the rows contain four Senior ends and for the rest balanced sibships. It would seem as if a selection procedure here would meet an S excess. There is, however, no longer any excess left in the birth cohorts of the figure, where each column (age stratum) is balanced. From 7: 5 we shall see that the S excess no doubt once existed, but to the right of the figure, in older and shorter columns.

Mortality will, in principle, cause no extra skewness. The characteristic S/J-quotient of a certain age stratum will also appear among those dying, among those left alive, and among those propositi who are selected randomly from that stratum.

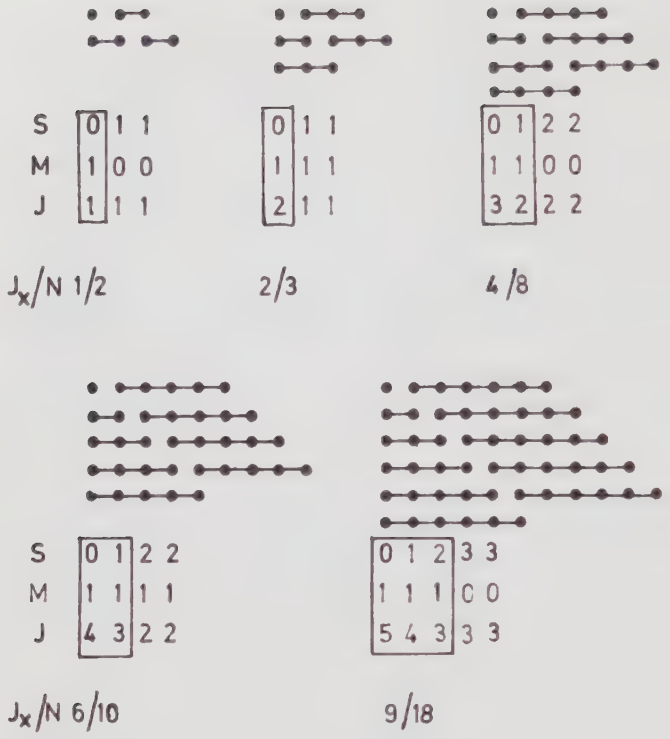


Fig 7: 2. Excess of lateborn in the youngest age groups. S = earlyborn. M = middle. J = lateborn. Quotient: about one half of a group consists of lateborn in excess.

The assertion that those left alive must predominantly be lateborn, since earlyborn tend to die first proves to be true within sibships (rows) but not in age strata (columns). When death attacks earlyborn within some sibships it also exterminates lateborn survivors in other sibships.

7: 4. SKEWNESS BECAUSE OF J EXCESS IN THE YOUNGEST PART OF A POPULATION

If newborn have no sibs, they are onlies. If they have sibs, they are lastborn and cause a J excess in their age stratum. Since all sibships are internally balanced (as many S as J), a compensating S excess must exist. It is located at the original beginning of a sibship row, in an age stratum where the population increased, perhaps centuries ago (cf 7: 5). Whereas a J excess arises among newborn because no later sibs can be known, the dead siblings of older people are known and form a shadow population leaving the same proportions of S and J as previously among living members of adult cohorts. When a sample (even a stable

Table 7:1. Excess of lateborn in the youngest D-columns.

	sibship size							
	2	3	4	5	6	7	8	9
excess quotient per skewed column	.5	.67	.5	.6	.5	.57	.5	.56
number of skewed columns	1	1	2	2	3	3	4	4
excess of lateborn per row	.5	.67	1.0	1.2	1.5	1.7	2.0	2.2

total population) contains people under the age of fifteen, however, we must expect to find an overrepresentation of lateborn in it. Fig 7:2 demonstrates the skewness for sibships of two, three, four, five, and six. The totals of S, M, and J are written below the columns of sibship members. The relative excess of J over S, expressed as the quotient of (J–S)/(S + M + J) in skewed columns is shown in table 7:1 for different sibship sizes.

Obviously, excess occurs in the first $\frac{s}{2}$ columns when s is an even number, in the first $\frac{s-1}{2}$ columns when s is uneven. The relative excess per individual in the skewed columns, multiplied by the number of such columns, gives the absolute number of excess individuals per row (= per member in one D-column). It should be noted that one member passing a D-column can give rise to several excess members in the population if he belongs to a large sibship. In general terms:

$$\text{J excess per row in sibships of s members} = .25\,(s - 1/s_u) \qquad \ldots \text{(formula 7:2)}$$

The minus term is used only when s is uneven. For s=9 we have $.25 \cdot \frac{80}{9} = 2.2$.

It should be pointed out that this application to a material of propositi requires some caution. Some of the apparently smaller families represent in reality larger but incomplete ones. For our calculation we should use the pattern of completed families in the somewhat older population and hope that the pattern will repeat itself among our propositi. If we use a pair that is really part of a five-sibling row, we underestimate the excess. In practice, we shall probably sometimes have to fall back upon mean sibship size among adults and to accept as

$$\text{absolute J excess in all sibships in the youngest part of the population} \approx .25\,\bar{s} \cdot D_1 \qquad \ldots \text{(formula 7:3)}$$

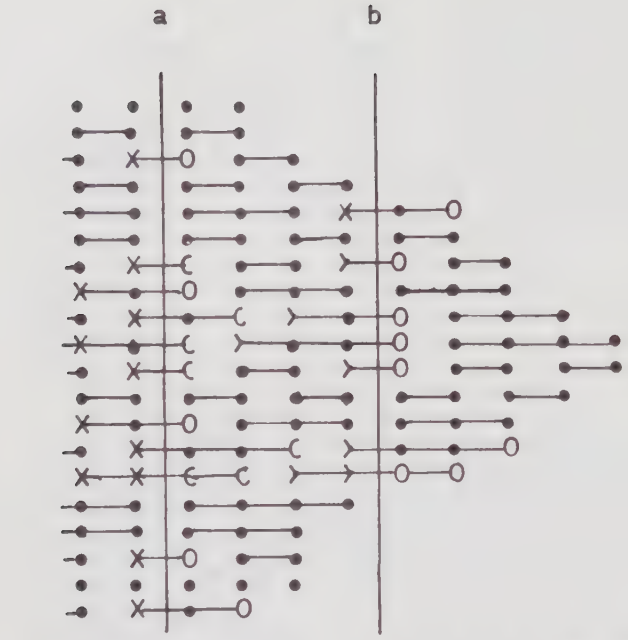


Fig 7: 3. An increasing population. Excess of earlyborn.
Age borders at a and b. S = Seniors. M = Middle. J = Juniors.
Excess of S: O; neutralized: (. Excess of J: X; neutralized:).

The coefficient .25 tends to underestimate excess when $\bar{s}$ is larger than 2, because large sibships add long rows of excess members but add much less to $\bar{s}$. A similar phenomenon appears in parts of the population where sibships are grown up and complete. Among them a larger coefficient, .36, is proposed by the writer (cf form. 7: 6), and it is possible that .25 is also too low among the youngest; the writer has no practical experience of birth orders in these age groups.

In any case, it is advisable to pay attention to the number of columns represented in a sample of children. If one works only with the first column (ages 0 – 3.5), one has to use the J-proportion from that column only, for instance 3/4 when $\bar{s}$=4, 5/6 when $\bar{s}$=6, as can be seen from fig 7: 2. The $\bar{s}$-value corresponds to that of completed families.

7: 5. SKEWNESS BECAUSE OF CHANGING SIZE OF COHORTS OF NEWBORN

The statements concerning the population model in fig 7: 1 have to be modified if the number of newborn is not the same in different years, or more specifically, in different dissemination periods. The members, dead and living, of an increasing population form a wedge-shaped diagram, as in fig 7: 3, widening from the narrow birth cohorts of former times to the broader strata of recently born children. In the narrower parts of the wedge, above line *b* we find a sprinkling of S in several age groups, with no J to counterbalance them in the same part of the row. The rule of complete internal balance within sibships tells us, of course, that corresponding J individuals exist somewhere in younger parts of the population, outside the age limits of the sample. This is a consequence of the fact that age limits, such as line *a* in fig 7: 1, are passed by some M and by about equal numbers of S and J. If a row has its upper (starting) end within the chosen part of the population (the sample), that row-end is well-balanced (J=S) if its youngest member is a lastborn, as in the second row of fig 7: 3, so that it contains only complete sibships. As soon as the row-end includes a fragment of a sibship, as in the third row, an excess of S arises.

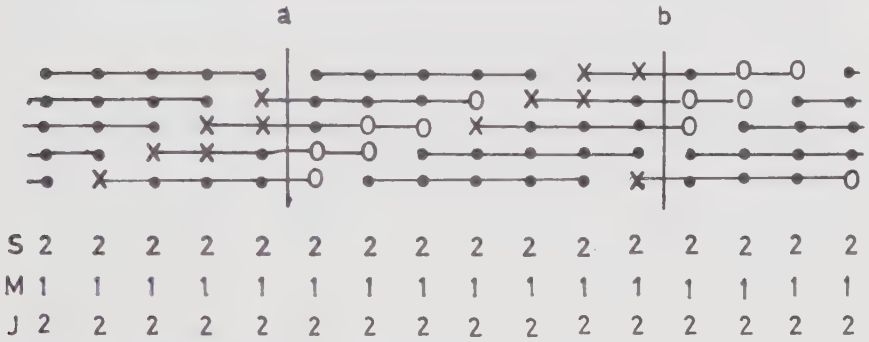


Fig 7: 4. Sibships of five passing age borders at a and b.
S = Seniors. M = Medians. J = Juniors. O=S in excess. X=J in excess.

Fig 7: 4 illustrates the production and extinction of excess members when sibships of five pass an age border from the left. Each column in this stable population is perfectly balanced: 2J, 1M, 2S. But an excess of S occurs in the rows. When rank I enters the sample (circle in the fifth row), the corresponding V remains outside (cross to the left). The same thing happens to II and IV. When IV passes, it outbalances II, and the passage of V extinguishes the excess. But as long as similar sibships continue to enter, each group of five sibships will maintain an excess of 6S, or 1.2 per sibship just passing. The number of such sibships is indicated by the number of their members in the first column above the border.

If we now introduce another age border between older columns (*b* in fig 7: 4), the balance of columns tells us that exactly the corresponding number of extra J members exists to the left of *b*, so the rows as a totality are still balanced in the population, quite as they should. To the right of *b*, however, we have the same S excess again, 1.2 per sibship of five. The excess will be transferred ad infinitum as long as sibships of any kind exist to the

right, even if some or all of their members have died. If, on the other hand, the row of older sibships stops below *b*, the S excess stays within the population between *a* and *b*. Such is the case in increasing populations, for instance in a freshly colonized area or in a population where more children are born than before. The excess has its source in the sibships crossing an age barrier, but it does not come into the open until the Senior ends of the earliest sibships in the row appear isolated.

In order to arrive at a quantitative evaluation of the excess we shall consider two examples.

A sibship of eight enters with 1S, then 2S, 3S, and 4S, next with 1J+4S, then 2J+4S, and 3J+4S. When 4J+4S have passed the age line, the excess is effaced. Thus, in eight steps 1, 2, 3, 4, 3, 2, 1, and 0 S have been in excess, on average 16/8 S. If the row of sibships continues across an older age border, and some J members are left behind at the transgression, this will constitute a similar J excess in the older part of the sample, outbalancing the S excess in its younger part. But if the row does not attain the next border, the passage has definitely added 2S to the sample.

A sibship of nine entails nine steps adding 1, 2, 3, 4, 4, 3, 2, 1, and 0 S, on the average 20/9, or 2.2 S. We note that the maximum value (four) remains unchanged when an M enters the sample.

Obviously, in the case of an even sibship size, here called s_e, the mean is $2(1+2+\ldots+.5s_e) - .5s_e$, divided by s_e, which reduces to $s_e/4$. When s is uneven (s_u), the mean is $(s_u{}^2 - 1)/4$, divided by s_u, or for comparison: $s_u/4 - 1/(4s_u)$. We get the formulae:

$$\text{average excess per row when a sibship passes an age line} = .25s_e \quad \ldots \text{(formula 7:4)}$$

$$\text{or} = .25\,(s_u - 1/s_u) \quad \ldots \text{(formula 7:5)}$$

where s_e denotes an even and s_u an uneven sibship size.

As long as any sibship is in the process of passing a border and still has a member located in the age group (the D-column) below the border, it adds an excess of S to the sample above (older than) the border line. The number of sibships of a certain size equals the number of members of such sibships within the D-column above the border, including last-born. The average excess per row (per member of that column) is shown in tab 7:2.

The S excess above an age border is originally the counterpart of the J excess in the youngest age groups (tab 7:1), but whereas that J excess is straightforward and permanent, always tinging the total population with a slight bias towards the J side, the S excess at a sibship passage is a rather thorny matter that needs a closer exploration.

Fig 7:3 will clarify the mechanism in more detail. It describes a population of children from the oldest sibships (to the right) down to the newborn, for example in a new settlement. The D_1 column contains twenty children, the D_2 column another twenty, the third column twenty who have entered school and are from seven to about ten years old. In columns older than D_4 the members are fewer, thirteen in D_6, four in D_{10}. In D_1 we find a lot of only children who have not yet had sibs, and also a great many J children, but no S, so we have a J excess of 12 individuals in 20 rows, that is, a quotient of .6. This excess is to some degree dependent on the combination of sizes and number of columns. We know from section 7:4 that the formulae derived there become somewhat thwarted when the

Table 7:2. Average excess of earlyborn or lateborn created when a sibship member is passing an age border.

sibship size													
1	2	3	4	5	6	7	8	9	10	12	14	16	18
0	.5	.67	1.0	1.2	1.5	1.7	2.0	2.2	2.5	3.0	3.5	4.0	4.5

excess has too few D columns in which to develop. The J excess in sibships of six in fig 7: 2, for instance, is only eight, not nine, in the first two columns, so a corresponding J excess below *a* and S excess above *a* in fig 7: 3 would stop at eight, too. Sibships of seven have a J excess of 6 in D_1, 4 in D_2, and 2 in D_3, so the excess would be restricted to 10 J in D_1 -D_2 and 10 S on the upper side of the division line, more specifically 10/7 per row, that is, 1.4 instead of 1.7, as tab 7: 2 would indicate.

After the division line *a* in fig 7: 3, the twenty members of D_3 consist of two only children, eight from (different) sibships of two, six from sibships of three, four from sibships of four, representing 10%, 40%, 30%, and 20% of the individuals in the column. Scanning the population between *a* and *b*, we detect S members in excess once in two rows of pairs, twice in three rows when families of three pass the border, four times of four among sibships of four, as expected according to tab 7: 2.

Now, if we look at the small children in D_1 and D_2, there is a heavy excess of J: 11 in D_1 and 1 in D_2. In the population from D_3 onwards no excess of any kind appears, as long as the total population of children is neither increasing nor decreasing. If, on the other hand, it is increasing from zero, we shall find an excess of 12 S located among the growing disseminates.

Fig 7: 3 also demonstrates the consequences of cutting out a part of the wedge between an upper and a lower age limit. Above line *a* we originally had our twelve excess Seniors in their sibships, for instance I and II of four, with III and IV still missing. Inspection shows, however, that seven of those twelve have become balanced by excess Juniors between *a* and *b*. Furthermore, an extra J (indicated by a cross immediately before *b*) has emerged, so the excess of S is reduced to 12–7–1 = 4, which tallies with the values in S–J at the bottom of the diagram. The remaining eight members in excess can be traced to sibships crossing *b*.

This play with simple models is all very well, but how far is it applicable to practical situations? How far can we expect that the average value of $\bar{s}$ will mirror a combination of s-values from tab 7: 2? A practical example may help to clarify this problem. In Swedish marriages, contracted in 1950 and still existing twenty years later, not childless, the number of children born in wedlock (31, 32) was the following in different birth orders: 38894 I, 30686 II, 14577 III, 5877 IV, 2169 V, 1421 VI-, totalling 93624, so that $\bar{s}$ = = 93624/38894 = 2.41 in wedlock in lasting fecund marriages. By subtracting II from I, III from II, etc., we get the number of sibships of 1, 2, etc., members, which are: 1) 8208 (21.1%); 2) 16109 (41.4%); 3) 8700 (22.4%; 4) 3708 (9.5%); 5) 748 (1.9%); 6 or more) 1421 (3.7%) = 38894 (100%). The percentages correspond to an n/s-column of families,

so that size times percentage yields 241%, or 2.41, as it should be. Each n_s, weighted by the excess coefficient of its s in tab 7: 2, contributes to a total excess of Seniors that amounts to about 1.70 out of 2.41, or .70 D. To insert $\bar{s} = 2.41$ into form 7: 4 or form 7: 5 would give only .60D or .50D and is clearly insufficient. Even .70D is an insufficient estimate, since sibships larger than six have not been properly weighted. A person who is one among twelve siblings actually signals, when passing a border, the hidden existence of 12/4 = 3 excess individuals on each side of the border. Those 3 make out a heavy addition to the excess in the sample, particularly as he himself adds only 1 to perhaps 200 propositi and not more than 1/12 to, say, 83 sibships (200/83 = 2.41). Each member of a sibship of size s adds an absolute excess of about s/4 individuals at his passage, so that n such members forming part of the border column add nearly ns/4, and the total D-column creates on each side an excess in the neighbourhood of $\Sigma(ns)/4$. This expression leads to some overestimation, however, because the addition from uneven sizes is somewhat less than s/4, from single children nothing at all. On the other hand, the approximation $.25 \cdot \bar{s} \cdot D = .25 \cdot \bar{s} \cdot \Sigma n$ will be mostly an underestimation. The difference between $\bar{s} \cdot \Sigma n = \bar{s}n_1 + \bar{s}n_2 + \ldots + \bar{s}n_{15}$ and $\Sigma(ns) = 1n_1 + 2n_2 + \ldots + 15n_{15}$ is $n_1(\bar{s}-1) + n_2(\bar{s}-2) + \ldots + n_{15}(\bar{s}-15)$. That difference rapidly becomes negative as soon as n_1 and n_2 do not dominate the distribution very heavily.

If we knew the distribution of sibship members $n_1, n_2, n_3 \ldots$ in the general population, we could easily estimate excess by means of tab 7: 2. If we knew $\Sigma(ns)$, we could also make a fair guess. If we know only $\bar{s}$, we can certainly state that the excess must be larger than $.25 \cdot \bar{s} \cdot \Sigma n$ (or $.25 \cdot \bar{s} \cdot D$), but how much larger is it? When cohorts from seven decades among 2,000 propositi were tested by means of table 7: 2, the absolute excess varied between $.32(\bar{s}D)$ and $.40(\bar{s}D)$. In the student sample it was $.33(\bar{s} \cdot D)$. The writer suggests $.36(\bar{s}D)$ as a reasonable estimate and has used, in his model of the general population, the approximation

$$\text{absolute number of excess S or J in a D-column above or below point i (an age border)} \approx .36\,\bar{s}_i D_i \qquad \ldots\ \text{(formula 7: 6)}$$

As stated before, the excess is tied to the passage of sibships across an age border (fig 7: 7), and the transit is marked by the existence of a sibship member in the border column. As soon as the youngest member has left the border, the excess vanishes, but then other sibships will have entered, preparing an excess production of their own. The S excesses above the lower age border are usually balanced by J excesses below the upper age border. Only if the passage across such older lines is performed by fewer sibship representatives, does some degree of S excess persist as a net excess in the population between the lines. If, on the other hand, the representatives should be more numerous in older times (cohort size has decreased), the result is a net excess of J as in fig 7: 7. Such excess values (S_X or J_X) are absolute, indicating a number of individuals.

Whereas formulae 7: 4 and 7: 5 concern the excess generated in a row when a sibship member passes a border, formula 7: 6 estimates the excess generated along a D-column

when sibship members from all sibship sizes pass the column. Neither formula, however, tells whether the excess persists in the sample or is counter-balanced by a loss at another border. We have to determine the *net excess*, N_X.

In a sample limited by two age borders, for example i and j, the net excess ($N_X = J_X - S_X$) is the difference between the excess at j and that at i. If we let the subscript i refer to the year of birth of the youngest in the sample and the subscript j to the year of birth of the oldest, we could describe the absolute net excess in the sample as

$$\text{absolute net excess between age borders } N_X = .36(\bar{s}_j D_j - \bar{s}_i D_i) \quad \ldots\ldots \text{(formula 7: 7)}$$

A positive N_X means a net excess of Juniors, a negative N_X a net excess of Seniors.

The absolute net excess indicates a number of individuals, irrespective of the size of the sample or the time span between its age borders. We also need to know the relative net excess. If N_t represent the members of the sample, all born during the t years between j and i, the proportion of excess members in the sample gives the

$$\text{relative net excess between age borders } N_X/N_t = .36(\bar{s}_j D_j - \bar{s}_i D_i)/N_t \quad \ldots\ldots \text{(formula 7: 8)}$$

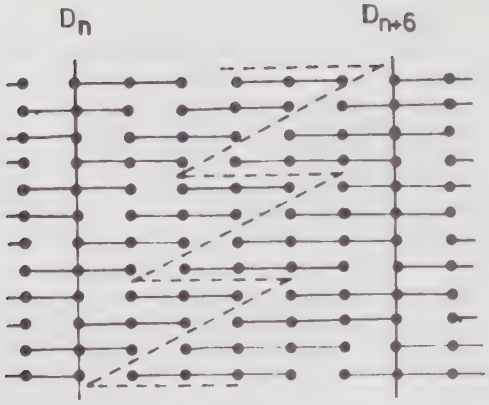
By means of a transformation described in section 7: 7, we can express the relative excess as a deviation from middle position.

7: 6. SKEWNESS BECAUSE OF CONTINUALLY CHANGING MEAN SIZE OF SIBSHIPS

Section 7: 5 considered mean sibship sizes that differed from age border to age border. When sibship size changes continually during the period between age borders, such changes generate skewness of position, but the skewness is essentially the same phenomenon only expressed in another manner as in section 7: 5.

Fig 7: 5 depicts a gradual transition from sibships of four to sibships of three in a population of constant size. The transition is supposed to take place over six dissemination periods. To the left is a dissemination column D_n without any excess (4 S, 4 M, and 4 J), to the right a dissemination column D_{n+6} that is about 20 years older, again without excess (6 S and 6 J). Columns between D_n and D_{n+6}, however, contain 23 S, 10 M, and 27 J, or 4 J in excess.

Though the excess becomes evident only in the central columns of the sample, it actually expresses the excess that has arisen along the age borders. Sibship ends that have passed D_n contain 8 S and 4 M, whereas ends to the left of D_{n+6} contain 3 S and 15 J, leaving a net excess of 15 – 3 – 8 = 4. All sibships that do not touch the borders are, of course,



S	4	4	4	4	5	6	6
M	4	4	3	2	1	0	0
J	4	4	5	6	6	6	6
J-S	0	0	1	2	1	0	0 = 4

Fig 7: 5. Decreasing family size. Twelve transitions from sibship size 4 to sibship size 3 in six disseminations. Four extra J. S: Seniors. M: Medians. J: Juniors.

perfectly balanced internally and add no excess to the row. Notwithstanding, they may transfer skewness from the borders to the age columns in the centre.

The writer has studied in detail a great many models of continually changing sibship size, for example from s=4 to s=2, from s=6 to s=3, and so on. They all lead to the same result as that found in the previous section and expressed by formula 7: 8.

7: 7. SKEWNESS OF SIBLING POSITION IN THE GENERAL POPULATION EXPRESSED AS A MEAN POSITION

Sections 4, 5, and 6 of this chapter have described methods to determine approximate excess numbers and excess proportions of earlyborn (S) or lateborn (J) in the general population. We may wish to compare such proportions with those found in some sample of propositi. When using standard deviations of sample proportions for judging the significance of a difference between the sample and the general population, we must remember, however, that the population proportions of excess are approximate so our conclusions should be modest.

Chapter 5 described methods for determining several characteristics of the propositus sample and of the baste population, such as sibling interval, sibship size, and mean sibling position. Table 5. 2 demonstrated how the mean position in the total sample can be judged (and misjudged) by its deviation from a theoretical mean of 5, as has been the custom in most studies.

A correct procedure would imply comparing the mean of a sample with the real position mean of a corresponding general population. Such a task, however, meets with considerable difficulties. We could try to take representative samples from different birth cohorts in the general population; each sample would have its own characteristics regarding skewness, family size and cohort size. Sampling should preferably be random, not restricted to specified contrast groups.

Lacking such population samples, we could try to use the information on skewness that has been described in this chapter, aiming at population means located in different decades. But before attacking the task, we must survey several difficulties.

Table 7:3. Position values in sibships of 1-6 members.

Sibship size	Lateborn			Middle			Earlyborn		
1				.5					
2			.75		.25				
3		.833		.5		.167			
4	.875		.625		.375		.125		
5	.9		.7		.5		.3		.1
6	.917	.75		.583		.417	.25		.083

We arrange sibship positions in a table with all M in the middle, all J to the left, and all S to the right, as in table 7: 3. In a non-skewed population, N_0, we expect in principle n_S/s persons in each position, $\Sigma p_S = n_S/2$ in each row, and $\bar{p} = .5$ in each row as well as in the total sample.

But even in this ideally balanced population the mean position of all J or of all S has no fixed value but varies with the n_S-values. When s is even (s_e), the mean of S positions in a row is .25, but when s is uneven (s_u), the mean is lower, namely $.25 - 1/(4s_u)$. This value is .17 for s=3: .20 for s=5; .22 for s=9; thus rising slowly towards .25. The mean of all Seniors would lie somewhere between .167 and .25 but vary with the distribution of different sibship sizes which is our first difficulty.

Next, a group of S or J passing a border may have a mean that is particularly deviating. The S excess above an age border (fig 7: 4) is mainly founded on firstborn, whereas the corresponding J excess below a border is dominated by lastborn.

Third, the last member of a large sibship has a more deviating position value than the first member of a small sibship. When family size decreases and such values appear in the same column, they seem to balance each other ($J-S = 0$) but the sum of their positions is

larger than twice .5, so the position mean moves in the J-direction. The combination .167 and .875, for instance, adds .042 to the population sum of positions even before excess members appear. The phenomenon needs some closer inspection.

In fig 7: 5 there are five columns containing sibships of different size. Adding the position values within each column, one finds a total excess value of 1.083. Since there are four J_X in the figure, the same result would have occurred if each J_X had contributed .27 in addition to .5, that is, if its mean position had been .77. Similar transitions from three to two siblings produce such a deluge of high values that each J_X entails 1.08! Such analyses certainly show that a change in average family size may under some conditions cause a skewness that is much heavier than the number of excess individuals indicates. Obviously, we cannot combine rigid theoretical models in order to find a reasonable value of the mean position of excess members.

In this complicated situation, we have to resort to a practical estimate of the mean position of those forming the net excess of S_X or J_X in a sample. It is convenient to call the total sample population N and the net number of excess members N_X, whereas the rest of the population, N_0, is balanced, containing as many S as J, so that $N = N_0+N_X$. We further postulate that the mean position of N_0 is .5, though we know from the analyses above that the statement is not always strictly true.

If the mean position of N_X is called $\bar{p}_X$, the sum of positions of the sample is $\bar{p}_{tot}N = .5N_0 + \bar{p}_X N_X = .5N + (\bar{p}_X - .5)N_X$. At this point, we introduce an excess coefficient $e = \bar{p}_X - .5$, which is negative when N_X consists of S_X members with their low p_X and positive for J_X members. The mean position of the sample (form 5: 4) can be analysed as

$$\bar{p}_{tot} = .5 + e \cdot \frac{N_X}{N} \qquad \text{. . . . (formula 7: 9)}$$

Now, if we can estimate the proportion of excess members in a certain population (perhaps born many decades ago and all of them dead), we may get an idea of the position skewness that existed in that population, on condition that e, the multiplier for transformation of relative excess into deviation, does not vary beyond narrow limits when samples are large and the deviation marked. We might guess that the mean position of all S_X (say, .20) and the mean position of all J_X (say, .80) should be about equally distant from .5, so that the numerical value of the distance, or |e|, is about the same in both cases.

To test this hypothesis, we may begin with the student sample tab 5: 2. Counting each sibship size separately, we find in the second row 35 − 50 = −15, in the third row 18 − 33 = = −15, in the sixth row 7−5 = +2, and so on. The net excess, N_X, is +5 −46 = −41, the relative excess $N_X/N = -41/302 = -.1358$. Since the mean position of the sample is .4628, the deviation is .4628−.5 = −.0372 = e(−.1358). In this case, we arrive at e = .2740, which is a first approximation.

We certainly have to apply this kind of computation with some caution. If we write form 7: 9 like this: $e = (p - .5)\, N/N_X$, is is immediately noticeable that e is highly sensitive to the difference between p and .5. A random addition of .0010 to p = .5005 makes

Table 7:4. Twenty-two samples where the mean position deviates more than .0400 from .5000. Size of sample: N. Earlyborn or lateborn in excess: N_X. Relative excess: N_X/N. Relation between deviation and relative excess: e.

Type of sample		Deviation	N	N_X	Rel. excess	e multiplier
2,000	1920-29	.0459	458	62	.1354	.3391
I	1920-29	.0482	138	23	.1667	.2891
III	1890-99	−.0669	43	−9	−.2093	.3196
III	1910-19	.0515	140	24	.1714	.3005
III	1920-29	.0636	130	24	.1846	.3445
III alc	1910-19	.1239	47	18	.3830	.3235
III alc	1920-29	.0891	45	13	.2889	.3084
III not alc	1920-29	.0501	85	13	.1529	.3277
women	1880-89	.0694	23	5	.2174	.3192
men	1920-29	.0517	369	55	.1491	.3467
not alc	1920-29	.0402	275	29	.1055	.3810
alc all	1890-99	−.0422	83	−13	−.1566	.2695
alc all	1920-29	.0583	183	36	.1967	.2964
neurosis	mixed	.0460	212	31	.1462	.3146
neurosis	1890-99	−.0463	22	−3	−.1364	.3394
neurosis	1910-19	.1177	56	22	.3929	.2996
neurosis	1920-29	.0471	52	9	.1731	.2721
schizophr.	1930-39	.0640	25	7	.2800	.2286
encephalopathy		.0478	94	16	.1702	.2808
III somatic diagn.		−.0493	69	−14	−.2029	.2430
students	1920-29	−.0431	37	− 4	−.1081	.3987
students	1940/41	−.0546	19	− 3	−.1579	.3458

e = .3131 ± .0397; error of e: .0087

e rise to three times its former value, but the same addition to $\bar{p}$ = .5200 increases e only by 5%. Our estimate of a reasonable e-value must start from a $\bar{p}$ that differs considerably from .5.

Further, one and the same number of S_X may lead to different p-values in a row. In a subsample of the students in tab 5: 2 (not demonstrated here), with N = 67, N_X = −1, relative excess = .0149 and p = .5069, eight persons belonged to sibships of four, distributed like this: 2–3–0–3, so that $\Sigma p_S = (2 \cdot 1 + 3 \cdot 2 + 3 \cdot 4 - 8/2)/4 = 4$. If the distribution had been 3–2–3 0, the sample values of N, N_X, and relative excess would have remained untouched, but Σp_S had been 12/4 = 3, so that $\bar{p}$ of the subsample would have decreased

by (4–3)/67, from .5069 to .4920, and e would have changed from .0069/ -.0149=-.46 (!) to -.0080/ .0149 = .54. This is another reason why we should only examine cases where the deviation from .5 is large so that the skewness is firmly established among propositi.

A great number of experiments have shown the writer that deviations below .0400 give unstable estimates of e. Therefore, only samples that have a deviation larger than .04 have been chosen, the deviation divided by the relative excess and the resulting value of e recorded in tab 7: 4. The mean of e in 22 samples is .3131 + .0087, with a standard deviation of .0397. In the following, the writer will use the approximate value of e = .3.

The term N_X in form 7: 9 includes excess members of every kind. How they have entered the sample does not matter. Some may represent a general population with its skewness, some may have been selected according to some biassed sampling principle. We may thus lump together the excess members of form 7: 7 and insert the sum into form 7: 9.

The expected mean position in the general population caused by differences in fertility and mean sibship size can therefore be written, after transformation by the e-multipher:

$$\bar{p}_{tot} = .5 + .3 \cdot .36 \, (\bar{s}_j D_j - \bar{s}_i D_i) / N_t \qquad \ldots . \text{(formula 7: 10)}$$

7: 8. TESTING THE SIGNIFICANCE OF SKEWNESS

Most studies on birth order concern the question whether a connection exists between a trait and an "over-representation" of a certain birth order. If a mean position deviates significantly from .5, however, it may yet represent birth orders in the general population correctly, and still less does it prove a connection with the observed trait. Neither can we use a χ^2 test under the assumption that individuals ought to be evenly distributed over the birth orders of this or that sibship size individuals in real populations are not.

Instead, we have to ascertain the actual mean position of siblings in the general population from which the sample is taken. After that, we may decide whether we prefer to consider the difference between the population mean and the sample mean significant or not.

One may compute such a population mean by collecting and examining a sample of the general population, taking care to ensure representativity and randomness and to make the sample large enough to provide a sufficiently small error of the population mean.

In this chapter, another method is suggested, using ready-made official nativity statistics in order to procure large numbers. The model is intended to estimate the mean sibling position of such members of a general population as were born during a specified period of time. It is built upon three kinds of value: 1) average sibship size (s) at the time, 2) average sibling interval in years (w) at the time, 3) number (N) of children born in the general population during the specified period.

Section 7: 9 will report estimates of average sibling size (tab 7: 5) in birth cohorts of the general population. Since the average sibling intervals in these cohorts seem to be unknown, the writer has used the intervals in the sociomedical cohorts, computed as in tab 5: 4. Sec-

tion 7: 10 will describe the choice of nativity values (tab 7: 6) in birth cohorts of the general population.

Certain time subscripts applied to s, w and N may need comment. The subscript i indicates a certain moment, for example the moment in the year 1920 when somebody was born. For a person who is older, the subscript j is used, for example the moment of his birth in 1912. In practical work, "moment" corresponds to a time unit (a day, or a year). The subscript t, on the other hand, corresponds to a series of time units between the moments j and i, for instance the nine-year period 1912–20. While N_t is the number of children born in the general population during t years, N_t/t is their mean per annum, sometimes referable to a certain moment i.

Now, to avoid a host of subscripts, the writer has sometimes applied i, j, and t to symbols where they do not strictly belong but where they will hardly cause confusion. Thus, a mean sibling interval w_t is supposed to refer to a moment roughly in the middle of a certain period of t years. A dissemination column of births, D_i, refers to a period of w years, but the subscript locates the centre of the period.

7: 9. FAMILY SIZE IN THE GENERAL POPULATION

In 1766, a statistician estimated average sibship size in Sweden and arrived at a number of about four (177). For the decades after 1870 Quensel (295) has gathered material. He used age-specified fertility rates in order to estimate family size when the married mother had attained 45 years of age. By this method one would arrive at 5.4 children born in wedlock in the 1870's, 5.25 in the 1880's, 4.97 in the 1890's, 4.66 ten years later, 3.81 after 1910, 2.83 in the 1920's, 2.20 in the 1930's, about 2.6 in the 1940's. Hofsten (169) states that women born in 1850 had 4.3 children, those born around 1905 had 1.8, those born around 1935 had 2.2 . According to Quensel, children born out of wedlock became legitimated to 35% in the 1890's, to 60% around 1960. The latter proportion agrees with that given by Hyrenius et al (175), and in the late 1960's two thirds to three fourths of children born out of wedlock became legitimated (177).

An official Swedish report (356, p 191) states that the average size was 4.73 for marriages contracted in 1902, 4.45 for those from 1905, 4.04 for 1910, 3.5 for 1915 (duration of marriage at least 21 years). Quensel (357) gives a value of 3.29 for 1910–15 (p 234) and of 2.36 for 1940 (p 263), when 42% were firstborn and the subsequent ranks counted 25, 16, 8, 3, 4, and 1%, respectively. Hofsten (168) gives the number of children per woman born 1870/71 as 3.7; 1880/81: 3.2; 1890/91: 2.5; 1900/11: 1.87; 1930: 2.2; 1940: 2.0. He further (167) gives the cohort fertility values of 4.20 in 1750, 4.70 in 1800, 4.30 in 1850, 4.0 in 1860, thus pointing to considerably higher values concentrated to married women thirty years later.

Two population surveys (109, 110) have described Swedish family size defined as all children, including those absent or dead, in families with married parents still living together. Stepchildren and own premarital children were excluded, as well as children of unmarried or widowed persons or of parents not living together. Thus many smaller sibship sizes remained unrepresented. The number in completed marriages (= wife older than 44 in 1930) was for marriage years 1901–05: 4.83; 1906 -10: 4.25; 1911–15: 3.45. In cities

Table 7:5. Estimated mean sibship size in the general population, s_g, and observed mean sibship size in the sociomedical samples.

Decade	$\bar{s}_m$	P_e	u	$\bar{s}_g$	obs.
1870-79	5.40	16	.65	3.85	–
1880-89	5.25	15	.65	3.85	3.05
1890-99	4.97	15	.65	3.72	3.54
1900-09	4.66	13	.60	3.78	3.80
1910-19	3.81	14	.60	3.23	3.18
1920-29	2.83	15	.55	2.61	2.65
1930-39	2.20	17	.50	2.16	2.43
1940-49	2.60	17	.45	2.53	2.62

$\bar{s}_m$ = mean size of completed offspring of married couples
P_e = percentage of extramarital births
u = unlegitimated proportion
$\bar{s}_g$ = estimated mean sibship size in the general pop.
obs = observed mean sibship size of the patients

larger than 30,000, the corresponding numbers were 4.35; 4.02; and 3.50. The 1935–36 survey (110) arrived at lower national values – 1901–6: 4.62; 1907–11: 4.11; 1912–16: 3.46; 1917–21: 2.70. Comments in these reports stressed the complicated nature of the figures.

For Gothenburg, the 1936 survey (143, p 20) showed that marriages contracted 1901–15 had 3.64 children, those contracted 1916–20 had an offspring of 2.63. In the population study of 1968/69 by Bengtsson et al (38, 39), 1462 women (1173 mothers) in Gothenburg, aged 38–60, were randomly sampled through the Revenue Office Registers. Dr. Bengtsson (40) has kindly extracted and sent the writer the number of children per mother born in 1908 (2.17 ± .17), 1914 (2.15 ± .09), 1918 (2.18 ± .06), 1922 (2.19 ± .06), and 1930 (2.29 ± .06).

Obviously, we cannot compare the size of offspring of marriages directly with the size of sibships in general. A sibling born in 1915 can be the offspring of a marriage contracted several years before or afterwards; his sibship size may have become restricted because of the death or divorce of his parents; he may be the only child of an unmarried mother. On the whole, we expect sibships to be smaller than the offspring of marriages of long standing. The number of unmarried mothers must be quite considerable since, as a rule, new unmarried families enter the picture each time the married families continue their childbearing. In the 1950's (112, p 39), 18% of unmarried women 30–39 years old were mothers; those who had had a child before they were 29 were not registered as mothers if the child

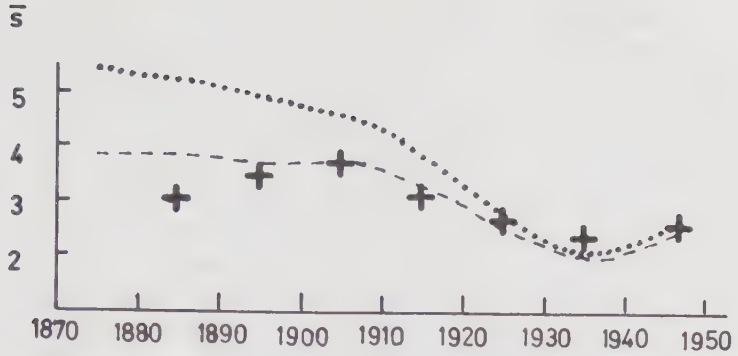


Fig 7: 6. Mean sibship sizes.
Upper curve: mean size of offspring of married mothers older than 45.
Lower curve: estimated mean size of completed families of every kind (tab 7: 5). Cross marks: mean size of sibships of sociomedical cases.

lived elsewhere, with grandparents or in a fosterhome, so the number of unmarried mothers must have been larger. Those with children at home had 1.3–1.4 children in 1960, so the real number may have been about 1.2 at that time and somewhat above 1.0 also in earlier decades.

In 5: 3 the writer has proposed a formula estimating general sibship size s_g. The formula is built upon the following values: sibship size in marriages of long standing, s_m; the percentage P_e of extramarital births; the proportion u of extramarital children who do not become legitimated; the sibship size s_e among such children. Formula 5: 2 runs: $s_g = 100\, s_m / (100 - P_e + P_e u\, s_m / s_e)$. In our case, we have to consider the composition of our sample, half rural, half metropolitan in its origin. The P_e-values are therefore larger than the national ones. Tab 7: 5 registers P_e-values (from two decades earlier), as well as s_m-values given by Quensel (295) and u-values interpolated between .65 in 1890 and .40 in 1960. The s_e-value is kept at 1.0, slightly too low, but the somewhat inflated s_m-values may compensate roughly for this. The last column of tab 7: 5 registers the sibship sizes observed in our samples (tab 6: 4). The series of estimated s_g-values and that of observed values differs by one standard deviation in the 1880's and by slightly more in the 1930's.

Fig 7: 6 shows the curves of sibship size: the curve in marriages of long standing, the estimated population curve and the curve observed in the sample of 2000 propositi.

The writer is inclined to accept the s_g-values as reasonable estimates of sibship size in a half rural, half metropolitan population during the decades indicated. The values will serve in the construction and application of a population model of skewed sibling positions described in a later section of this chapter.

Table 7:6. Annual mean of live births in different decades and at the beginning and the end of decades.

Period	Sweden	Gothenburg
1878-81	135143	2660
1880-89	135886	2965
1888-91	134408	3337
1890-99	133418	3375
1898-01	136979	3741
1900-09	137092	4135
1908-11	136745	4526
1910-19	125981	4242
1918-21	124906	4307
1920-29	110293	3842
1928-31	94006	3217
1930-39	90173	3405
1938-41	96708	4208
1940-49	121455	5663
1948-51	118384	5959

7: 10. BIRTH COHORT SIZE IN THE GENERAL POPULATION

Skewness because of nativity variations is always connected with some sort of age border (birth date). The skewness does not become manifest, however, until the size of D-columns changes with increasing or decreasing nativity somewhere between two borders. In the analysis of such changes, we must use nativity values that are valid at a special moment i in the middle of the dissemination period. The writer has tried four alternatives, built on average nativity in the general population in 1932–30, in 1931–29, in 1931––28, and in 1929–27. The means of these periods are roughly at 1.7.1931, at 1.7.1930, at 1.1.1930 and at 1.7.1928 (the latter near the middle of the D-column concluding the decade). The corresponding values for all decades between 1880 and 1950 were tried in the survey of the four alternatives. The outcome of the trials was very much the same with respect to skewness, but the N_4/4-type (the mean per annum of 1941–38, for example) seems preferable because it permits a broad comparison with the content of a dissemination period of 3 – 3.5 years and since we can use s- and w-multipliers referring to the first and last day of a decade. Nativity values of this type are given in tab 7: 6 for decades and for decade borders from 1880 to 1950.

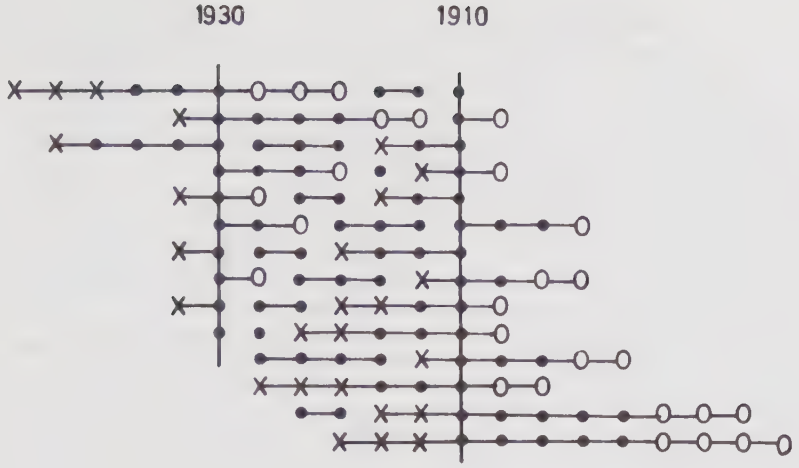


Fig 7: 7. Simulated representation of the general population between 1910 and 1930. Excess of Seniors: O. Excess of Juniors: X. Sibling intervals in reality shorter in large sibships.

7: 11. THE MEAN POSITION OF MEMBERS OF A SIMULATED POPULATION MODEL

Before we apply our methods to real quantities, we may illustrate their use by means of a simulated population sample from the two-decade birth cohort of 1910–29, with its oldest members (of 1910) to the right and its youngest (of 1929) to the left in fig 7: 7. The J who arise below the age line at 1.1.1930 create an equal number of S_X exactly balancing them above the age line, in 1929 and before. On the other hand, their numbers will mostly differ from those of J_X and S_X arising at other age lines, for example at 1.1.1910. In describing the 1910–29 population, we must decide where to locate our dissemination columns along the borders. Obviously, our S_X start in the youngest part of fig 7: 7 during the dissemination periods before 31.12.1929, our J_X during the dissemination periods following after 1.1.1910.

In fig 7: 7 the borders are placed at the middle of the D-columns, half of which belong to the sample. They have been chosen so that J and S cancel each other along the border columns. The members in 1910 have the values $\Sigma n = 14$; $\Sigma(n/s) = 4.04$; $\overline{s}_j = 3.47$. In 1930 the values are $\Sigma n = 10$; $\Sigma(n/s) = 3.86$; $\overline{s}_i = 2.59$.

The population between the age borders has the size $N_{20} = 79$ for $t = 20$. From our propositus material we estimate the distance w between D-columns to about three years – interpolation points to 3.04 for 1910 and 3.27 for 1930. Any D-column has the size $w_i N_i$, where N_i is the annual mean of live births around moment i. In this case we have decided beforehand that the size should be 14 for 1910 and 10 for 1930, which is roughly proportionate to the population birth cohorts in those years.

Formula 7: 6 has the form $.36\,\bar{s}_i D_i$. For 1910, we arrive at an excess of $.36 \cdot 3.47 \cdot 14 = 17.5$. For 1930 we have $.36 \cdot 2.59 \cdot 10 = 9.3$. We pass to formula 8: 6 in order to compute the difference between these excess values so we may estimate the net number of excess individuals in the sample between the borders. They are $17.5 - 9.3 = 8.2$ extra J (J, because the difference is positive). In fig 7: 7 we find $18 - 9 = 9$. Dividing the estimated absolute number by the total number of live births between 1910 and the end of 1929, we get the relative excess according to formula 7: 8: $(17.5. - 9.3)/79 = .1038$. This is our estimate of the relative excess due to birth cohort size, sibship size and sibling interval at the borders.

Ultimately, we have to weight the excess proportion by .3 in order to transform it into a deviation from .5, the middle value. Thus, $.3 \cdot .1038 = .0311$. The mean position of the simulated 1910–29 population would be something like .5311. As we shall see from tab 7: 7, the real numbers in the general population lead to a position between .53 and .54.

7: 12. PRACTICAL APPLICATION OF THE POPULATION MODEL OF MEAN POSITIONS

We shall now apply the model to real numbers, constructing table 7: 7. The values we need for construction of such tables are to be searched for in the following sources:

Source 1: Annual number of births in the corresponding general population. Average values are determined for each birth cohort period and for the moment of its start and the moment of its ending, as in tab 7: 6.

Source 2: Average size of completed families to which members of a birth cohort in the general population belong. If no ready-made figures are available, the size must be estimated from statistics concerning offspring of married mothers, percentage of extramarital births, proportion of legitimated children and size of extramarital families, as in tab 7: 5.

Source 3: Average sibling interval is computed from average values in families with two or more children, applied to the actual distribution of sibship sizes in the general population at a certain moment. If such values are not available, they can be replaced (293, p 641) by distributions registered in the propositus sample, as in tab 5: 4. The influence of average intervals on the outcome in tab 7: 7 is in any case modest.

The frame of tab 7: 7 consists of an upper margin and a left-hand margin. In the upper margin we indicate the age borders in our sample between 1880 to the right and 1950 to the left. The left-hand margin determines the content of the rows.

Table 7:7. Estimated mean position of sibship members in different birth cohorts of the corresponding general population.

	1950	1940	1930	1920	1910	1900	1890	1880
1. $\bar{s}_t$	2.53	2.16	2.61	3.23	3.78	3.72	3.85	
2. $\bar{s}_i$	2.42	2.35	2.39	2.92	3.50	3.75	3.79	
3. w_t	3.51	3.36	3.18	3.09	2.98	2.89	2.92	
4. w_i	3.62	3.44	3.27	3.14	3.04	2.94	2.91	
5. N_i Gothenburg	5959	4208	3217	4307	4526	3741	3337	2660
6. D_i Gbg	21572	14476	10520	13524	13759	10999	9711	
7. N_t Gbg	56630	34050	38420	42420	41350	33750	29650	
8. N_i Sweden	118384	96708	94006	124906	136745	136979	134408	135143
9. D_i Sw.	428550	332676	307400	392205	415705	402718	391127	
10. N_t Sw.	1214550	901730	1102930	1259810	1370920	1334180	1358860	
11. $.36(\bar{s}_i D_i)$ Gbg	18794	12247	9051	14216	17336	14849	13250	
12. $.36(\bar{s}_i D_i)$ Sw.	373353	281444	264487	412286	523788	543669	533654	
13. formula 7:8 Gbg	−.1156	−.0939	.1344	.0735	−.0601	−.0479		
14. formula 7:8 Sw.	−.0757	−.0188	.1340	.0885	.0145	−.0075		
15. .50(13.) + .50(14.)	−.0956	−.0564	.1342	.0810	−.0228	−.0277		
16. .3(15.)	−.0287	−.0169	.0403	.0243	−.0068	−.0083		
17. estimated mean position	.4713	.4831	.5403	.5243	.4932	.4917		

Symbols: t = period of time; i = point of time; s = sibship size; w = average sibling interval in years; N_i = number of births per year; N_t = number of births per t years; D = number of births per w years.

Row 1. registers the mean sibship size, $\bar{s}_t$, of each birth cohort of ten years. The writer has here followed the numbers of Quensel and their transformations in tab 7: 5.

Row 2. estimates mean sibship size in the general population at a certain moment i between the t-periods. The $\bar{s}_i$-values were interpolated from $\bar{s}_t$.

Row 3. starts from the average sibling intervals w_s found in the propositus samples, applying them to the patterns of sibling distribution within the different birth cohorts of propositi in order to estimate w_t. The patterns of different cohorts in the general population were not known to the writer.

Row 4. estimates the size of average sibling interval at certain moments i. The w_i-values were interpolated from w_t. They develop along an evenly sloping curve. Their standard deviations are not known, which might affect the reliability of the mean positions in row 17.

Row 5. registers the mean number of live births per year in Gothenburg around a certain moment i. This number, N_i, is calculated as the average of two years before and two years after the moment i, that is, the first day of each decade.

Row 6. weights N_i for Gothenburg by the w_i-value borrowed from the samples in order to estimate $w_i N_i = D_i$, that is, the number of children born within the dissemination period of w_i years. Before the end of that period they cannot, as a rule, be expected to have a younger sibling.

Row 7. registers the total number of live births, N_t, in Gothenburg during a period of t years between moments j and i; t = 10.

Row 8. registers the annual mean of live births in Sweden during four years around moment i.

Row 9. weights N_i for Sweden by the w_i-value borrowed from our sample, in order to estimate D_i for Sweden.

Row 10. registers the total number of live births, N_t, in Sweden during t years between moments j and i; again, t = 10.

Row 11. estimates the absolute number of excess individuals created in Gothenburg on each side of the age line i when the population passes that line (formula 7: 6 and fig 7: 7).

Row 12. estimates the absolute number of excess individuals created in Sweden at moment i.

Row 13. shows the difference between the absolute excess numbers at j and i in row 11 (the net excess $N_X = J_X - S_X$), divided by N_t in row 7, in order to give the relative excess, N_X/N_t, in Gothenburg. In a growing population, where $N_t > N_j$, the sign of the proportion becomes negative, indicating $J_X < S_X$, that is a net excess of early-born and a mean position lower than .50.

Row 14. shows the difference between the absolute excess numbers at j and i in row 12, divided by N_t of row 10., in order to give the relative excess in Sweden at the period.

Row 15. weights row 13. and row 14. according to the relative contribution of Gothenburg natives to the sample. In this case, the weights .5 and .5 were used, since the proportion of patients born in Gothenburg was very nearly one half.

Row 16. transforms the relative excess proportions into deviations from a balanced sibship position of .5. For the transformation, the weight .3 has proved more appropriate than the schematic weight of .25.

Row 17. adds .5 to row 16. in order to arrive at an estimate of the mean sibling position of members of the general population born during the t years between j and i.

The values of row 17. are represented graphically in fig 7: 8. The upper margin of the figure registers the year, the left margin the first two decimals of the position. The curve in fig 7: 8 makes it clear that our logical deductions have led to a series of mean positions that show a quite characteristic configuration. We thus expect people who are born between 1890 and 1910 to display a fairly balanced distribution of sibling positions – almost as many lateborn as earlyborn. Between 1910 and 1930, the picture changes dramatically: lateborn grow much more common than earlyborn. After 1930 an abrupt reversal occurs: earlyborn suddenly become dominant again.

Now, how far can we trust this model? The theoretical considerations, the preparatory study of detailed mechanisms, the numerical formulation of position skewness, as well as the patching together of such pieces into a comprehensive structure – all this constitutes no proof that the model gives a reasonably accurate description of the influence of nativity, sibship size, and sibling interval on birth order distribution in birth cohorts. Still less can we claim that other and better models could not exist.

7: 13. ALTERNATIVE MODELS

Actually, the writer has considered a long row of models, all of them more or less logically unsatisfactory in the end, some built on families (not on individuals), some on too narrow restrictions, some on overoptimistic approximations, etc. A rather reasonable one was intended to exclude onlies from formula 7: 6, on the grounds that only children do not produce any S or J at the borders. If their number is n_1 and their proportion is $a = n_1/\Sigma n$, the mean size of the remaining sibships is $(\Sigma n - n_1) / (\Sigma \frac{n}{s} - n_1)$, which is equal to $\bar{s}(1-a) / (1-a\bar{s})$ and of course larger than $\bar{s}$. The corresponding D-column is reduced to $D(1-a)$, so the product is $\bar{s}D(1-a)^2 / (1-a\bar{s}) = \bar{s}D[1 - a(2-a)]/(1 - a\bar{s})$. This expression grows larger than $\bar{s}D$ as soon as the mean size of the total sample is larger than $(2-a)$. With $a = .1$ and $\bar{s} = 3$, for instance, the "border excess" would increase by one sixth. The method seems inapplicable in practice, however, as long as we lack precise knowledge of the proportion of onlies in the general population at different times.

We could further try models based on only one of the components used in tab 7: 7. Variations in the sibling interval values borrowed from our patient samples are not very promising, however, since the values simply form a smoothly rising curve from 1890 to 1950.

From fig 7: 16, on the other hand, we find that the mean sibship sizes that were derived from values in the general Swedish population behave in a manner that makes them obviously connected with position estimates. Rapidly decreasing sibship size, manifested as a difference between $\bar{s}_j$ and $\bar{s}_i$ in formula 7: 6, is accompanied by a preponderance of lateborn: members of larger sibships dominate for a while when sibships become smaller.

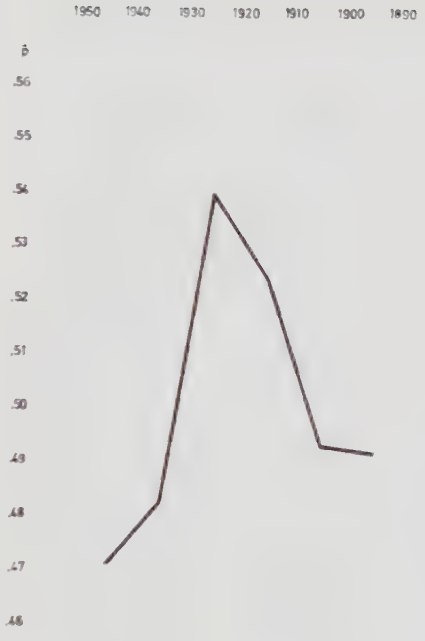


Fig 7: 8. Expected mean sibling position in a general population. Values from tab 7: 7.

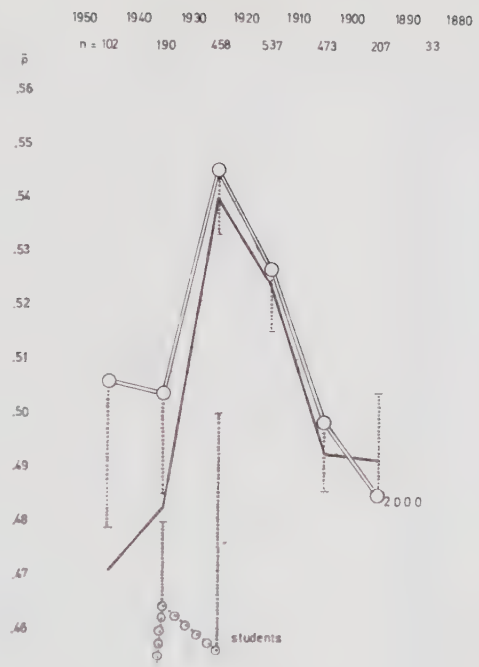


Fig 7: 9. Observed mean sibling positions and mean errors in 2,000 sociomedical cases and in 302 students, compared with expected positions.

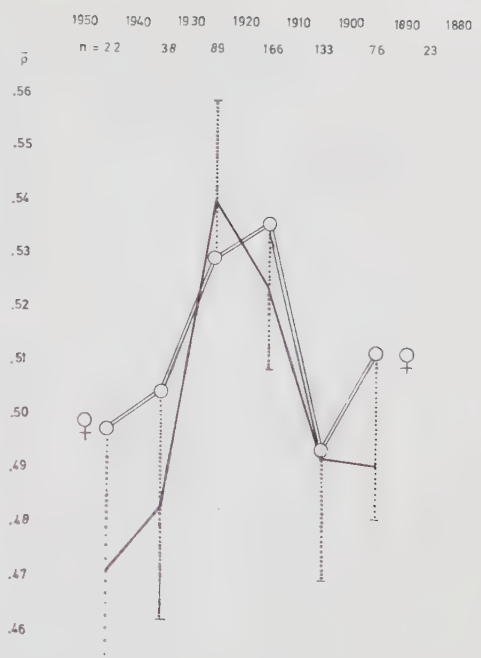


Fig 7: 10. Observed mean sibling positions and mean errors in 487 female sociomedical cases, compared with expected positions.

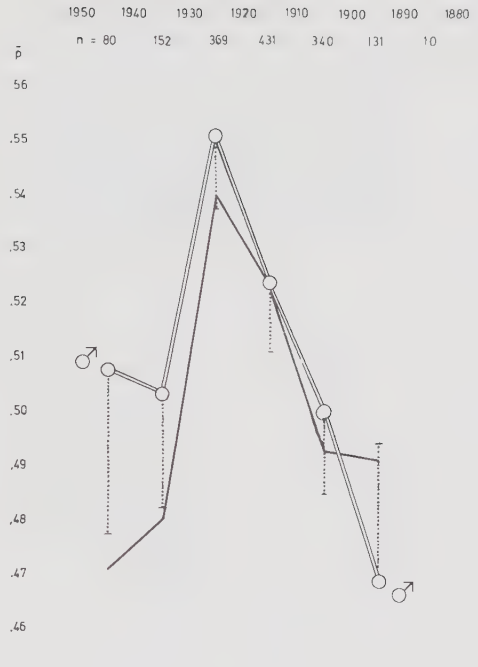


Fig 7: 11. Observed mean sibling positions and mean errors in 1,513 male sociomedical cases, compared with expected positions.

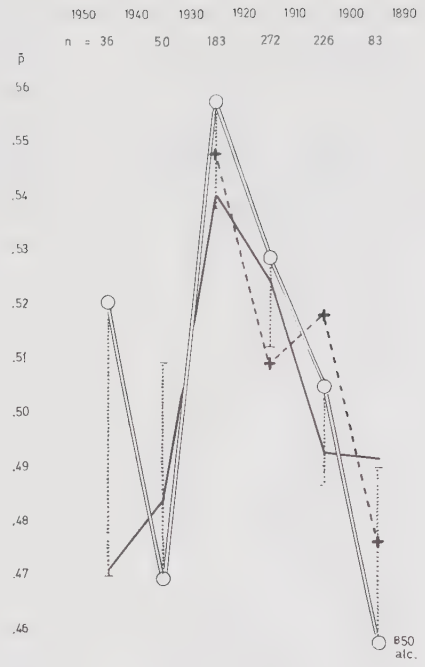


Fig 7: 12. Observed mean sibling positions and mean errors in 850 alcoholics (607 in group I and 243 from group III), compared with expected positions. Group I also depicted separately (broken line).

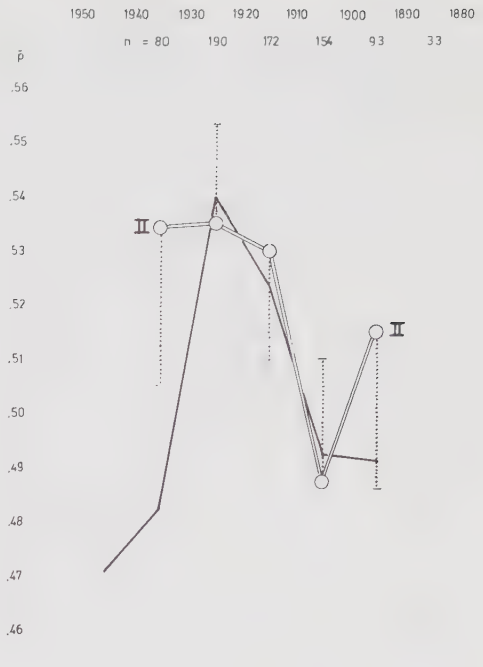


Fig 7: 13. Observed mean sibling positions and mean errors in group II (722 sociomedical cases), compared with expected positions.

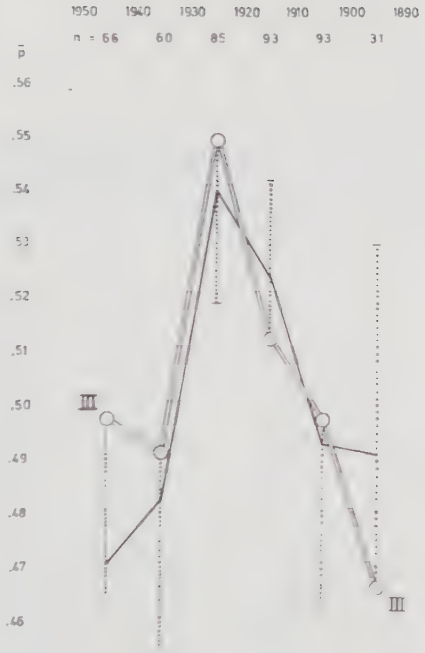


Fig. 7:14. Observed mean sibling positions and mean errors in group III with 243 alcoholics excluded (423 sociomedical cases), compared with expected positions.

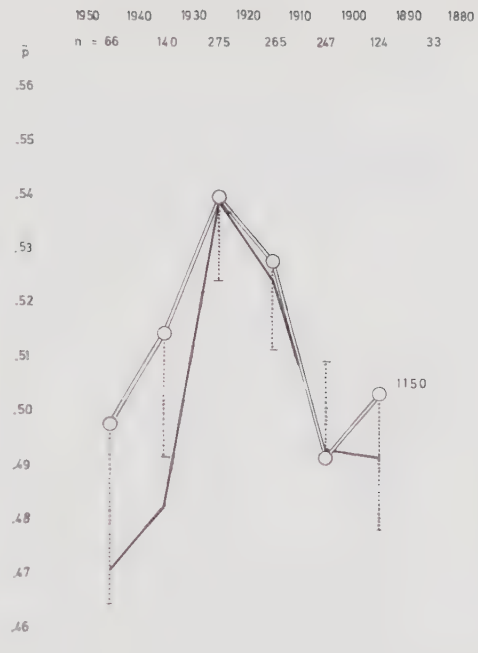


Fig. 7:15. Observed mean sibling positions and mean errors in 1,150 sociomedical cases with a main diagnosis other than alcoholism, compared with expected positions.

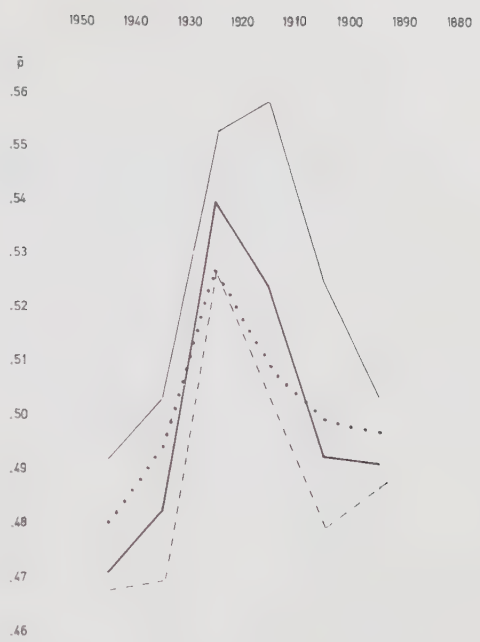


Fig. 7:16. Population values represented in the diagram of expected positions in fig. 7:8. Rearranged from tab. 7:7 to form crude parameters. Thin line: $.5+(s_j - s_i)/t$.
Dotted line: $.5+(N_j - N_i)/N_t$ in Sweden.
Broken line: $.5+(N_j - N_i)/N_t$ in Gothenburg.

In fig 7: 16, $(\bar{s}_j - \bar{s}_i)/t$ is arranged as a deviation from .5 in order to facilitate comparison with the estimates. The curve presents a special feature worth noticing: after adjustment to an appropriate scale, the sibship size differences in all decades, save in 1920–29, lie markedly above the position estimates.

This feature is of interest when we consider the birth cohort components, one from Sweden in general and one from Gothenburg (fig 7: 16). The relative difference between cohort sizes ten years apart, $(N_j - N_i) / N_t$, has been added to .5 to make comparison easier. In both cases we find an impressive change in relative cohort difference in the decades between 1910 and 1930. The Gothenburg values lie markedly below the position estimates, so the curve of estimates is influenced both by sibship size and by cohort size.

The comparisons in fig 7: 16 make it tempting to ask: why not simply use one of these curves, for instance one of relative cohort difference, with some suitable weight? Why could it not function just as well as the complicated model in fig 7: 8?

To this suggestion there are several objections. First, the very mechanism behind skewness of position is intimately connected with our model, but not with any serendipitous findings among census numbers. Next, the dimensi ons of the curve are not dependent on an arbitrary application of "suitable" weights but on real values, such as sibship size, sibling interval, production of excess by sibships of different size, computation of the average position of excess individuals. The weight of .36 in formula 7: 6, as well as the e-value of .3 (tab 7: 4), were determined long before tab 7: 7 was completed. Third, the invention and the rejection of models, and the numerous trials of false paths have proved very helpful in attaining more intimate knowledge of the mechanisms. Familiarity with the problem may entail improvement of the models in the future. Fourth, the three component models do not describe estimates of position but simply differences in sibship size and cohort size, even though they agree fairly well with the position estimates.

7: 14. ESTIMATED AND OBSERVED POSITIONS

The agreement just mentioned is primarily an expression of the principles underlying the construction of the model. These principles are theoretically closely connected with position values, but we still have no proof that they describe positions in practical experience.

A comparison with our total sample of propositi (fig 7: 9) shows, however, a good agreement between estimates and observed values, possibly with the exception of the last decade (1940–49), where the curves deviate by 1.39 S.D.

Judging from fig 7: 8, we would expect lateborn to be heavily overrepresentated in population strata from the birth cohorts of 1910–19 and 1920–29. This hypothesis finds corroboration in group after group of propositi, provided such groups are large enough. Fig 7: 10 demonstrates the phenomenon in 487 female patients, fig 7: 11 in 1513 male patients, fig 7: 12 in group I (607 male alcoholics) and in the enlarged group (607 + 243 alcoholics from group III). Fig 7: 13 shows a similar skewness in group II (722 patients with social problems other than alcoholism, examined 1948–59), fig 7: 14 in group III with 243 alcoholics excluded (428 patients from the period 1960–73), fig 7: 15 in 1,150 patients with a main diagnosis other than alcoholism. When we come down to smaller

subgroups of the total sample, however, the pattern is no longer discernible and the errors of the means are too large.

Among the positions in fig 7: 12 one finds the original observation which caused such confusion and debate, and which started the whole program of investigation. It has the form of a zigzag line from earlyborn alcoholics in the 1890's to lateborn in the 1920's. It was certainly a lucky coincidence that this material contained precisely the two extremes that must arouse attention and call for an explanation.

No explanation has, however, been found as yet for the late mean position of the youngest cohort (1930–39) of group II, fig 7: 13, as well as of the youngest cohort (1940–49) of group III, fig 7: 12 and fig 7: 14. It may be noteworthy that the 1930–39 cohort later seems to have moved to its expected position in both samples from group III, fig 7: 12 and fig 7: 14, where its members were at least ten years older than in group II. Is it reasonable to suspect that lateborn persons tend to manifest their social problems at a younger age than earlyborn do? Or does the fact that, in both cases, the elder half of the youngest cohort contains twice as many members as its later half imply that the cohort is dominated by characteristics resembling those of the next-youngest cohort? Or does the 7: 4-effect extend as far upwards as to propositi aged 17–20 at the time of referral? Future researchers may find answers to such questions.

Chapter 8

DISCUSSION OF MEAN SIBLING POSITION AS A CENTRAL PROBLEM OF BIRTH ORDER RESEARCH

Birth order research starts from the general idea that the ordinal position of a person in his family may exert an influence on his fate.

The influence may operate through a unilateral activity. A person, a law, a custom may authorize a decision to bestow dignity, wealth, power or training on a certain sibling, for example the eldest one (primogeniture). Some parents may insist on giving special protection to the youngest child. Even if the decision is not always deliberately directed towards a certain birth order, its consequences may unintentionally take this direction.

The influence may also originate in complex epidemiological circumstances, such as a rising socio-economical status of the parents.

The kind of influence particularly discussed in birth order literature is supposed to arise as a result of interaction between siblings or between parents and their children, for example delivery hazards, infections, distribution of roles, parental deprivation.

Literature in the field has mainly focussed on correlations between ranks and sociomedical or sociopsychological traits. Galton claimed in 1874 to have ascertained the eminence of firstborn. At the beginning of the present century, Pearson found that firstborn were handicapped and a threat to society. Weinberg showed in 1913 that the conclusion was due to erroneous logic and miscalculation. In 1914, Greenwood and Yule laid down rules for the numerical treatment of problems of birth rank and family size. Their rules have dominated birth order research since then.

The first author to cast doubt upon their model was J A Cobb. As early as in 1914 he pointed out that the model presupposed a balanced distribution of ranks around a point halfway between firstborn and lastborn. If a sibship is regarded as a unit, ranging from 0 to 1, its earlyborn members have positions below .5, its lateborn above .5. Though this is true for a particular sibship, it does not apply to siblings from different sibships. Yule accepted Cobb's objection that certain factors will move the mean position to values other than .5, but he seems to have overlooked the fundamental importance of this flaw in his own reasoning, and he did not change his model.

For the subsequent four or five decades the difficulty was ignored. Certainly, several authors compared their sociomedical propositi with social twins or other controls, but without discussing their reasons, only as a matter of general precaution. The majority of investigators relied on a .5-model, however, and constantly arrived at results as conflicting as those of Galton and Pearson.

In 1959, the present writer constructed a model which included the idea that mean sibling position in the general population necessarily changes from decade to decade. In

1969, Hare & Price published theoretical considerations showing that skewed sibling position can arise from reasons similar to those stated by Cobb. In 1971, Birtchnell explicitly declared that the Greenwood-Yule model was erroneous and misleading. His solution included the definition of a target population, partly from city areas, partly from small-town or rural parishes. By means of a postal survey he secured information concerning birth order and family size from 3425 persons representing the corresponding general population above 20 years of age. Among those born in a certain period and belonging to sibships of five, for example, each birth order group contained sometimes more, sometimes less than 1/5, owing to a significantly uneven distribution. He then combined weighted percentages into expected values applicable to his samples (depressed patients, other psychotic patients, other neurotic patients, alcoholic patients, patients with personality disorders). Thus, firstborn in sibships of seven were expected to be 14.0 % in alcoholics, but only 10.2 % in patients with personality disorders. Constructing expected positions for each birth order cell in sibship sizes 2–10 in five tables (270 values), Birtchnell performed detailed χ^2 comparisons between the population and the propositus distributions, both of them skewed. No consistent deviations emerged.

The writer had approached the problem along similar lines, starting from the fact that birth order distribution is skewed. The 1959 model, however, does not use information directly procured from a control sample of individuals in the general population. Although it is built upon empirical figures, the figures are of a more general kind: decade values of fertility, of average family size and of average sibling interval. A system of formulae, derived by means of a logical analysis, leads to a quantitative description of the regular skewness of birth order distribution expected in different age groups.

The present study is intended to show certain properties of regular sibling position skewness:

1) a definite pattern of skewness exists which can be traced from birth cohort to birth cohort in different groups of sociomedical cases: in three groups examined during separate periods; in groups of women and men; in groups of patients with and without a main diagnosis of alcoholism;
2) the form of the pattern is consistent with cohort changes of fertility and sibship size in the general population;
3) such changes can explain the mechanism of pattern formation;
4) the explanation permits the construction of a model expressed in quantitative terms;
5) the model allows predictions that later development has corroborated;
6) the new technique offers a possibility of using a defined and very large control population, without selection and examination of limited population samples.

The findings support the following suggestions of which the last one is presented for the first time.

Since the mean sibling positions in all birth cohorts of the general population are skewed, situated sometimes below, sometimes above .5, a fortuitous selection of probands from different cohorts or a certain cohort may produce any illusory sham effect or conceal any true effect, as long as some model of even distribution of ranks is applied. All such models must be abandoned.

Skewness is a comprehensive concept covering all sorts of deviation from even birth order distribution. One of its forms is the regular skewness inherent in all populations. Overrepresentation is another form, which is characterized by its deviation from regular skewness. No statements concerning overrepresentation should be attempted before regular skewness has been taken into account.

Propositi from a certain birth cohort and a certain geographical area should be compared with control material from the same cohort and the same area.

Since the selection of control individuals is time-consuming, costly and laborious, so that a procedure involving such selection is likely to discourage some researchers from the study of birth order effects, the writer proposes an abbreviated method which is rapid, cheap and fairly efficient. Its use will help to prevent mistakes which have hitherto tended to discredit birth order research.

SUMMARY

The *introduction* outlines the history of the investigation, from a discussion in the 1930's to the systematic collection of birth order information in the late 1940's. A first survey in the 1950's of the accumulated information led to the confusing experience that older alcoholics were more often earlyborn, young alcoholics lateborn. A population model was built in 1959 on the basis of theories formulated that year. A plan of investigation secured the collection of additional facts which made it possible to crossvalidate and complete the model. In 1974 the ultimate survey started. A first version of June 1979 has undergone numerous changes. Many scientists gave advice in this respect and in questions of publishing.

Chapter 1 aims at giving an orientation over sibling position and skewed distributions of birth order.

Chapters 2 – 4 survey about 400 studies in the field, with special attention to those concerned with principles of sampling and evaluation. Chapter 2 reviews a century of statements on birth order distribution of types of trait-carriers in sociomedical and sociopsychological studies. Chapter 3 discusses epidemiologic influences on birth order distribution. Chapter 4 gives an overview of models used by authors for description of birth order problems.

Chapter 5 is devoted to methods of computation concerning sibling distribution, sibship size, sibling position and sibling interval.

A particular sibship size (s) is represented in a sample by n_S persons who indicate the proportional existence of n_S/s families in the basic population. The mean sibship size is then $\bar{s} = \Sigma n_S/\Sigma(n_S/s)$. The variance of all sizes is $\Sigma(n_S s)/\Sigma(n_S/s) - (\bar{s}^2)$.

The position of a propositus with ordinal number r is given as $(r - .5)$ s. The mean position of all propositi in a sample is then $\Sigma \frac{\Sigma r - .5 n_S}{s} / \Sigma n_S$. The variance of a position within a sibship of size s is $(s^2 - 1) / 12s^2$. A weighted mean of such variances, increased by squared differences, leads to the variance of positions within the total sample.

The concept of sibling interval is of fundamental importance in the subsequent analysis: the average interval between all siblings in families of two or more. All children in a population who are born during a period of time equal to the prevailing mean sibling interval (for example 3.2 years) form a birth cohort where it is unusual to find sib pairs but very usual to find persons who have siblings born in neighbouring periods. The writer proposes the term "disseminate", D, for such cohorts, as if they were created by an act of sowing germs ("dissemination") at regular intervals corresponding to the mean sibling interval, w, in the population.

The methods of computation are illustrated by samples from the student material.

Chapter 6 is concerned with the origin and the analysis of the empirical material. The first five sections account for the sampling and the epidemiologic background. Since no target population was chosen from the beginning, one has to accept that the propositi represent basic populations of different origin, imperfectly defined. Two main groups of propositi were sampled: 302 students at a Graduate School of Social Work, and 2,000 patients referred to the Social Medical Officers in Gothenburg.

The subsequent sections of chapter 6 describe the distribution of birth order and sibship size in subgroups of propositi reported in tables A: 1–32 in the Appendix. The rules of computation laid down in chapter 5 lead to results displayed in tab 6: 4 and in figures 7: 9–15. The main finding is a significant skewness of mean position, changing in a systematic manner from decade to decade. The pattern of skewness is repeated from subgroup to subgroup: in women, in men, in alcoholics and in others, as well as in groups sampled at different times. Among the patients, earlyborn dominated in the 1890's, lateborn in the 1920's, while those born in the 1930's returned to a relatively balanced distribution.

Literature abounds with statements (often conflicting) that firstborn, or earlyborn, or lateborn, or lastborn, are overrepresented in some group or other of propositi. With the exception of a few studies on matched groups, such statements start from the tacit assumption that sibling positions balance each other and have .5 as their self-evident mean. Though such a mean necessarily characterizes every particular sibship, it can arise only by sheer coincidence among members of different sibships. The mean position of the birth cohort of 1920–29 among the students is located at about one mean error distance from .5, but it deviates almost twice that mean error from the mean position of the corresponding cohort among the patients (CR 1.98) and in the model (CR 1.92). We have here the opposite example: a significance that would have been overlooked if the .5-model had been used.

Chapter 7 sheds light on the question whether it is the students, or the patients, or both, who deviate from the general population as far as sibling position is concerned. The chapter elaborates the principles laid down by the writer in a manuscript in 1959 and put in practice in an investigation published by Holmgren in 1960.

The reasoning starts from some obvious facts.

A population of newborn cannot contain any but single children and lastborn siblings, so its sibling position is heavily skewed in the direction of lateborn. In a settlement containing solely young families with small children, the first working years of a nursery school, or of elementary school classes will have populations of pupils who are nearly all of them single or earlyborn: the same is true about the first contingents enrolled for military service from the area. This is an effect of changing size of disseminates.

A sample limited by two age borders contains an excess of earlyborn among its youngest, an excess of lateborn among its oldest members.

Decreasing sibship size in the population entails a net excess of lateborn, and also an excess of extreme individual positions in those lateborn who are formally balanced by earlyborn of smaller sibships. Even a cursory glance at tables A: 1–32 will show how a dwindling family size produces skewness: a streamer-like concentration along the diagonal down to lateborn of large families.

The excess influences emanating from such mechanisms are too complex to be set down exactly and in detail. The writer has treated them from a logical point of view and constructed a population model by means of approximate formulae built on cohort values of nativity, mean sibship size, and averaged sibling interval in the general population. Mean sibship size is here computed by means of a formula including data on extramarital nativity. Sibling interval values, as well as two weights, are derived from the empirical samples but do not systematically influence the form of the population model.

This model is intended to describe the skewness of mean sibling position in different birth cohorts (decades) of the general population in order to provide a standard with which to compare findings in groups of propositi, particularly concerning questions of overrepresentation of earlyborn or lateborn.

In the present study it appears that the patient population and its larger subgroups coincide closely with the model of the general population, whereas the student group deviates significantly in the direction of a preponderance of firstborn, signalling a mechanism of biassed selection.

A comparison of the population model with some of its components indicates that nativity variations and changes in mean sibship size in the general population play important roles in producing skewness of mean sibling position. Skewness of sibling position is the regular state in the birth cohorts of general populations. Conclusions dealing with overrepresentation of certain birth orders lack significance if they are founded on broad mixed cohorts or if they ignore the skewed mean position of siblings that is regularly present in all birth cohorts of the general population.

Chapter 8 discusses mechanisms which produce skewness of sibling position, such as deliberate selection, influences of the total social situation or interaction between family members. Main sources of skewness are changes in fertility and in average family size in the general population. The latter mechanisms create a characteristic pattern of skewness from cohort to cohort, which can be predicted by means of a model built on a logical and numerical analysis of population statistics. This pattern of skewness must be taken into account before any statements concerning overrepresentation can be attempted.

APPENDIX

BASIC TABLES OF BIRTH ORDER DISTRIBUTION

Table A: 1. Student cohort 1920–29.

Sib-ship size	Birth order						No.
	I	II	III	IV	V	VI	
1	8						8
2	4	3					7
3	4	3	2				9
4	2						2
5				1			1
6	1	1	1		1	1	5
7		1			1		2
8				1			1
9						1	1
10						1	1
							37

Table A: 2. Student cohort 1930–39 (cf Table 5: 3).

Sib-ship-size	Birth order									No.
	I	II	III	IV	V	VI	VII	VIII	IX	
1	46									46
2	41	29								70
3	28	18	16							62
4	8	7	3	7						25
5	6	8	2	2	3					21
6		1	1	1	3	1				7
7		1	1				2			4
8			1			1				2
9		1	1	1		1			1	5
10					1	1		1		3
11								1		1
										246

Table A: 3. Student cohort 1940/41.

Sib-ship size	Birth order					No.
	I	II	II	IV	V	
1	5					5
2	5	3				8
3	1	1				2
4	1					1
5				1	1	2
6						0
7	1					1
						19

Table A: 4. Group I, cohort 1890–99.

Sib-ship size	Birth order										No.
	I	II	III	IV	V	VI	VII	VIII	IX	X	
1	5										5
2	2	0									2
3	2	2	3								7
4	3	1	5	1							10
5	0	2	1	2	4						9
6	1	0	3	1	3	1					9
7		1					1				2
8			3				1	1			5
9	3		2	2			2				9
10	1	1			2						4
11		1					1				2
12		1	1	2							4
13	1								1	1	3
											71

Table A: 5. Group I, cohort 1900–09.

Sib-ship size	Birth order											No.
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	
1	8											8
2	11	12										23
3	8	2	7									17
4	4	8	2	4								18
5	3	7	11	6	8							35
6	2	6	3	4	4	6						25
7	2	1	2	3	0	0	3					11
8	3	1	0	4	3	1	2	0				14
9	0	2	1	2				2	2			9
10		1	1		1					1		4
11		1							1	2	1	5
12								1			2	3
13												0
14					1							1
												173

Table A: 6. Group I, cohort 1910–19.

Sib-ship size	Birth order															No.
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	
1	23															23
2	16	14														30
3	13	18	9													40
4	5	7	7	8												27
5	9	4	0	5	7											25
6	2	3	4	3	4	2										18
7	1	2	2	3	1	3	1									13
8	1	1	3	0	0	3	5	1								14
9		1	2	3				1	2							9
10	1		1	1	1		1	1	1	1						8
11			2	2		1			1	1	0					7
12	1								1		1	1				4
13						1						1				2
14		1												1		2
15																0
16													1	1		2
18											1					1
																225

Table A: 7. Group I, cohort 1920–29.

Sib-ship size	Birth order												No.
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
1	15												15
2	5	15											20
3	9	6	7										22
4	7	5	8	8									28
5	3	3	5	4	3								18
6	0	1	2	1	3	1							8
7	1	1				1	4						7
8	1				3	1		2					7
9					1			1					2
10		1	1	1			1			2			6
11											1		1
12						1							1
13		1										1	2
14						1							1
													138

Table A: 8. Group II, cohort 1880–89.

Sib-ship size	Birth order											No.
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	
1	5											5
2	3	0										3
3			1									1
4	1		2	1								4
5	2		1	1								4
6		1		1	2	1						5
7	1		1		1							3
8				1		1	3					5
9			2									2
10												0
11											1	1
												33

Table A: 9. Group II, cohort 1890–99.

Sib-ship size	Birth order											No.
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	
1	12											12
2	1	5										6
3	3	4	5									12
4	2	3	3	3								11
5	4	2	1	1	1							9
6		1	1		3	2						7
7	1	3	3	2		1	3					13
8			2	1	1	1	1					6
9			3	1					2			6
10	1	1		1	1							4
11			1								1	2
12		1		1						1	1	4
13												0
14											1	1
												93

Table A: 10. Group II, cohort 1900–09.

Sib-ship size	Birth order													No.
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	
1	15													15
2	8	3												11
3	4	3	4											11
4	6	4	6	7										23
5	2	6	4	2	2									16
6	2		1	4	2	5								14
7	4	2		5	3	1	5							20
8	4	1	3	1		3	3	1						16
9	1			1	3			1	0					6
10	3	1			2					1				7
11		2	2	1	1	1	1			1				9
12			1	1			1					1		4
13							1						1	2
														154

Table A: 11. Group II, cohort 1910–19.

Sib-ship size	Birth order												No.
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII . . . XX	
1	26												26
2	6	6											12
3	8	12	5										25
4	5	5	3	8									21
5	1	5	4	2	10								22
6	2	3	2	1	6	1							15
7	1	2	2	2	2	5	3						17
8	4			2	1	1	2	1					11
9	1	1		1	2		1	1	1				8
10		1	1		2					1			5
11						2				1			3
12							1					1	2
13									1			1	2
14		1											1
15				1									1
21												1	1
													[illegible]

Table A: 12. Group II, cohort 1920–29.

Sib-ship size	Birth order											No.
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	
1	39											[illegible]
2	11	13										[illegible]
3	8	12	13									[illegible]
4	3	8	3	6								[illegible]
5	5	2	3	1	8							[illegible]
6	1	1	1		2	3						[illegible]
7	1	1	1	6		3	3					18
8	1	1			1		3	1				[illegible]
9			3		1	1		1				[illegible]
10	1					1				2		4
11				1		2		1		1		5
12									1		1	[illegible]
13											1	1
14							1					1
15					1							1
												[illegible]

Table A: 13. Group II, cohort 1930 - 39.

Sib-ship size	Birth order													No.
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	
1	20													20
2	6	8												14
3	5	5	3											13
4	2	2	2	3										9
5	2		2	2										6
6	1		2	1	2	2								8
7	1						1							2
8			1				1							2
9			1						2					3
.														.
.														.
12												2		2
13													1	1
														80

Table A: 14.Group III, cohort 1890 - 99.

Sib-ship size	Birth order										No.
	I	II	III	IV	V	VI	VII	VIII	IX	X	
1	5										5
2	3	1									4
3			1								1
4	3	1	1								5
5	2		1	1	1						5
6	1				2						3
7		1		1			2				4
8			4	1	1						6
9	1								1		2
10	1	1			1						3
11			1							1	2
12			1					1			2
.											.
.											.
.											.
16				1							1
											43

Table A: 15. Group III, cohort 1900–09.

Sib-ship size	Birth order													No.
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	
1	9													9
2	3	1												4
3	6	6	3											15
4	5	8	2	4										19
5	5	4	5	5	4									23
6	4	4	1	6	2	4								21
7	2	6	2	1	1	2	3							17
8	1		3	2		1	1	2						10
9	2		1	1	1			3						8
10		1			2	1	1	1	1	1				8
11	1			1		1		1		1	1			6
12			1						1		1			3
13	1											1	1	3
														146

Table A: 16. Group III, cohort 1910–19.

Sib-ship size	Birth order														No.
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	
1	8														8
2	8	4													12
3	5	10	7												22
4	4	6	6	3											19
5	1	2	5	8	1										17
6	2	3	3	4	4	4									20
7	1	2	1	3	3	2	2								14
8				2		1	3	2							8
9	1			1	1	1			1						5
10						1		2		2					5
11	1			1							1				3
12											1	1			2
13							1								1
14								1	2					1	4
															140

Table A: 17. Group III, cohort 1920–29.

Sib-ship size	Birth order															No.
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	
1	21															21
2	8	6														14
3	5	7	2													14
4	2	6	8	10												26
5	4	4	2	3	3											16
6		2	1	3	3	3										12
7				2	2	1	1									6
8		1				2		2								5
9	1	1			1	1		1	1							6
10							1			2						3
11																0
12								1			1					2
13													1			1
14														2		2
15								1							1	2
																130

Table A: 18. Group III, cohort 1930–39.

Sib-ship size	Birth order										No.
	I	II	III	IV	V	VI	VII	VIII	IX	X	
1	12										12
2	8	13									21
3	12	9	7								28
4	5	3	2	1							11
5	4	2	2	2	4						14
6	1	1	1	5		1					9
7	4	1			2		2				9
8			1			1		1			3
9								1			1
10											0
11										1	1
12			1								1
											110

Table A: 19. Group III, cohort 1940–49.

Sib-ship size	Birth order								No.
	I	II	III	IV	V	VI	VII	VIII	
1	10								10
2	11	12							23
3	7	18	5						30
4	6		3	3					12
5	2	1		4	2				9
6	1		5			1			7
7		1					3		4
8			2					3	5
9									0
10		1				1			2
									102

Table A: 20. Women, cohort 1880–89.

Sib-ship size	Birth order											No.
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	
1	3											3
2	1											1
3			1									1
4	1			1								2
5			1	1								2
6		1		1	2	1						5
7	1		1									2
8						1	3					4
9			2									2
10												0
11											1	1
												23

Table A: 21. Women, cohort 1890–90.

Sib-ship size	Birth order											No.
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	
1	13											13
2	3	2										5
3	2	4	4									10
4	4			3								7
5	2	1		1	2							6
6		1			3	2						6
7	1	2		1			3					7
8			2	2								4
9	1		3	1					3			8
10		2		1	1							4
11			1								1	2
12		1						1		1	1	4
												76

Table A: 22. Women, cohort 1900–09.

Sib-ship size	Birth order												No.
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	
1	11													11
2	3	1												4
3	4	6	1											11
4	5	3	5	2										15
5	4	4	2	1	4									15
6	5	2	1	4	2	2								16
7	2	5	1	1	2	2	6							19
8	1		1			2	3	2						9
9			1		2			4						7
10	1	2			2				1	2				8
11	1	2	1	2	1	1		1		1				10
12			2				1		1		1			5
13							1						2	3
														133

Table A: 23. Women, cohort 1910 -19.

Sib-ship size	Birth order														No.
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	
1	11														11
2	4	7													11
3	5	8	6												19
4	1	2		4											7
5		2	4	4	2										12
6	1	1		3	1	1									7
7	1	3	2	3	2	1	2								14
8	2					1									3
9				1	3	1		1		2					8
10		1	1			1		1							4
11	1			1											2
12							1								1
13										1		1			2
14								1		2				1	4
15				1											1
															106

Table A: 24. Women, cohort 1920–29.

Sib-ship size	Birth order															No.
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	
1	11															11
2	3	6														9
3	7	5	6													18
4	2	3	3	2												10
5	2	1	1		2											6
6		2			1	3										6
7	1	1		6		1	1									10
8	1				1	1		1								4
9	1		2		1				1							5
10	1						1			2						4
11				1						1						2
12								1								1
13												1				1
14																0
15					1										1	2
																89

Table A: 25. Women, cohort 1930–39.

Sib-ship size	Birth order								No.
	I	II	III	IV	V	VI	VII	VIII	
1	7								7
2	3	4							7
3	4	3	2						9
4		1	1						2
5	1			1	1				3
6		1	1	1		1			4
7	2				1		1		4
8						1			1
9								1	1
									38

Table A: 26. Women, cohort 1940–49.

Sib-ship size	Birth order						No.
	I	II	III	IV	V	VI	
1	3						3
2	2	1					3
3	1	4	3				8
4	1		2				3
5				1			1
6	1		2				3
7							0
8							0
9							0
10						1	1
							22

Table A: 27. Group III alcoholics, cohort 1890–99.

Sib-ship size	Birth order				No.
	I	II	III	IV	
1	1				1
.					.
.					.
4			1		1
5	1			1	2
.					.
7		1		1	2
8			3		3
.					.
.					.
11			1		1
12		1			1
.					.
.					.
.					.
16				1	1
					12

Table A: 28. Group III, alcoholics, cohort 1900-09.

Sib-ship size	Birth order											No.
	I	II	III	IV	V	VI	VII	VIII	IX	X	XII	
1	4											4
2	2											2
3	1	2	1									4
4	1	5										6
5	2	2	2	2	1							9
6		1		2	1	2						6
7	1	1	1	1		1	1					6
8	1		1	2								4
9	1			1	1							3
10					2	1	1	1				5
11				1					1			2
12												0
13	1										1	2
												53

Table A: 29. Group III, alcoholics, cohort 1910–19.

Sib-ship size	Birth order														No.
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	
1	3														3
2	2	2													4
3		2	2												4
4	1	2	4	1											8
5		1		2	1										4
6		2		2	2	2									8
7	1		1	2	1		2								7
8							2	2							4
9	1														1
10										2					2
11															0
12												1			1
13															0
14														1	1
															47

Table A: 30. Group III, alcoholics, cohort 1920–29.

Sib-ship size	Birth order														No.
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	
1	6														6
2	2	2													4
3		1	1												2
4	1	3	2	5											11
5	2	1	1	2	1										7
6			1	2		1									4
7					1		1								2
8						2		1							3
9	1	1						1							3
10							1			1					2
14														1	1
															45

Table A: 31. Group III, alcoholics, cohort 1930–39.

Sib-ship size	Birth order										No.
	I	II	III	IV	V	VI	VII	VIII	IX	X	
1	5										5
2	6	7									13
3	3	3	4								10
4	3	1	1	1							6
5	3	2		1	1						7
6	1		1	1							3
7	2						1				3
8								1			1
.											.
.											.
11										1	1
12			1								1
											50

Table A: 32. Group III, alcoholics, cohort 1940–49.

Sib-ship size	Birth order								No
	I	II	III	IV	V	VI	VII	VIII	
1									0
2	4	5							9
3	3	7	3						13
4	1		1	2					4
5	2			1	1				4
6	1		3						4
7									0
8								2	2
									36

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Author's address:
Carl-Gustaf Berglin
Parkgatan 12
411 38 Gothenburg
Sweden